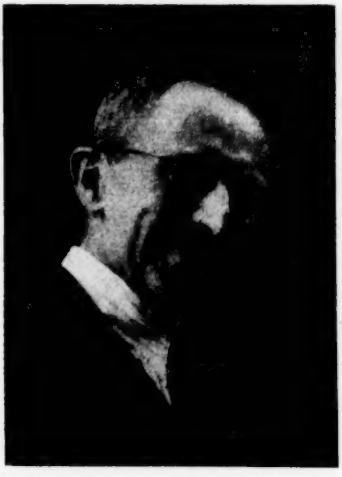
Popular Astronomy

Vol. LIV, No. 3 MARCH, 1946 Whole No. 533

Adriaan van Maanen
1884-1946

By ALFRED H. JOY

When Adriaan van Maanen came up for his doctorate at the University of Utrecht he took as the subject of his thesis "The Proper Motions of 1418 Stars in and near the Clusters *h* and χ Persei." Later, while at the Mount Wilson Observatory, his interest frequently returned to these well-known clusters and he continually hoped, by the use of a longer time interval and more powerful instruments, to improve the



ADRIAAN VAN MAANEN

accuracy of his results. One of his last research papers, submitted in April, 1944, less than two years before his death from a heart attack on January 26, 1946, presented the results of his recent measures of these stars. As an apology for so often returning to the same subject, he began the paper with the French adage, "On revient toujours à ses première amours," but to his friends he said, "How can I end my career better than by completing what I first began?"

According to this paper the annual proper motion of the Perseus clusters is +0″.0016 in right ascension and —0″.0023 in declination. In

this result van Maanen found the greatest satisfaction, and his attitude toward this tedious and extended investigation typifies his life-long ambition to carry out with the highest possible accuracy the most difficult measures known to astronomy.

He took his scientific work very seriously. Arriving at his Pasadena office earlier than his colleagues, he continued his routine of measurement and reduction day after day and year after year. He jealously guarded his allotted observing time with the telescopes on Mount Wilson and, in his eagerness to accumulate more observing material, often attempted photographs on nights which were unsuitable for good observations.

Aside from his astronomical work and associations, his chief interest was centered in a group of Pasadena friends, many of whom were fellow-members of the Valley Hunt Club. As a bachelor he was a welcome guest at many social functions where his exceptional facility in conversation made him an outstanding figure.

Adriaan van Maanen was born March 31, 1884, in Sneek, Holland. He took his academic training at the University of Utrecht, receiving his doctor's degree in 1911. During his graduate study he was fortunate in being allowed to spend some of his time at the Groningen Astronomical Laboratory where he came in contact with Professor J. C. Kapteyn, who thereafter became the guiding spirit in his life. The problems of stellar motions and distances which Kapteyn had so masterfully developed immediately attracted his unfailing interest.

From 1908 until 1913 Kapteyn, at the invitation of Dr. George E. Hale, paid an annual visit to Pasadena and Mount Wilson as an Associate of the Carnegie Institution of Washington. It was natural, then, that his young protégé from Utrecht should be attracted by the astronomical opportunities in America. Accordingly, he came to the Yerkes Observatory as a volunteer assistant in 1911 and spent a year there measuring the proper motions of stars in and around the Orion nebula.

Van Maanen readily adapted himself to the informality of American ways and without protest submitted to the nickname "van." He shared the sleeping quarters of the other young men (of whom the editor of this journal and the writer of this note were two) who were studying or working at the Observatory. In the winter we slept in the attic or under the floor of the 24-inch reflector and in the summer, in a tent set up outdoors on the ground. All went well until the occurrence of a heavy thunderstorm with terrific bolts of lightning striking in all directions so frightened him that he refused to sleep in the tent again.

In the summer of 1912, van Maanen came to Mount Wilson as a visitor and on September 1 was given an appointment to the staff of the Observatory. For two years he took part in the solar observations and the program of stellar spectroscopy. He also began the exceedingly difficult task of measuring the minute Zeeman displacements of the

solar spectral lines which might be affected by a general magnetic field in the sun. These arduous measures were continued for several years and are the only basis for a positive conclusion as to the presence of such a magnetic field.

In 1914 the equipment at the 80-foot Cassegrain focus of the 60-inch telescope for taking direct photographs was completed and a program of proper motion and parallax determination was carried on by van Maanen singlehanded for more than 30 years. His 500th parallax determination was completed in 1945. This number of stellar distances is greater than that of all that were known at the time he began his work. In these observations involving the most accurate positions from astronomical photographs, a reflecting telescope was used for the first time and it took courage to go ahead with the project in the face of much doubt and criticism. Van Maanen was able to prove that, with due care, sufficiently reliable parallaxes could be determined by such instruments and in 1920 a similar program for the fainter stars was inaugurated at the Newtonian focus of the 100-inch reflector.

For measuring the pairs of parallax plates, he introduced the use of the stereocomparator which he had tried out at the Yerkes Observatory for the Orion stars. He found that it was readily adapted to parallax measures and that the process of measurement and reduction was somewhat simplified in this way.

From 1914 until 1923, in addition to his parallax program, he spent a great amount of time and effort in an attempt to measure the internal motions in spiral nebulae by comparing plates taken at different epochs from 5 to 15 years apart. Although the material was not homogeneous, some of the plates being taken at the Cassegrain focus, some at the Newtonian, and some even with other instruments, the results were strangely accordant in showing a rotation period of the order of 100,000 years or, perhaps, a motion outward along the arms of the spirals. Slow as this motion is, it is much too rapid to be admitted with our present knowledge of the distances of these extragalactic bodies. The fact seems to be that the time intervals between the plates were too short and the observational material inadequate to cope with the difficulties of the problem. For the present, at least, we shall have to rely on spectroscopic results for our picture of the motions in the spiral nebulae.

Van Maanen was greatly interested in the distribution of stars in the neighborhood of the sun. Since this part of space is the only region where we may observe stars of extremely low intrinsic luminosity, he turned his attention more and more as the years passed by to the stars of the lowest absolute magnitude. Measures of distances and luminosity were made. By plotting the numbers of large proper-motion stars of different absolute magnitude he found a maximum at visual absolute magnitude 10.3 and thus reached the important conclusion that we

may not hope to find an indefinite number of stars of extremely low luminosity.

In 1917, van Maanen found in one of his parallax fields a 12th magnitude star of extremely low luminosity (absolute magnitude 14.3, parallax 0".244) whose color indicated a spectral type of G0. This white dwarf together with the companion of Sirius which had been previously observed by W. S. Adams attracted a large amount of interest and focussed attention on the problem of white dwarfs.

During his 33 years at the Mount Wilson Observatory van Maanen contributed 150 scientific papers. The more important results on proper motion and parallax were described in about 50 contributions. Many other papers are notes on individual stars and articles for the Holland journals and societies in which he kept up his interest.

Van Maanen maintained his membership in many societies, including the American Astronomical Society, Astronomical Society of the Pacific, Royal Astronomical Society, Société Astronomique de France, Astronomische Gesellschaft, International Astronomical Union, and a number of Holland scientific societies including the Amsterdam Academy; and he enjoyed attending scientific meetings where he could meet and discuss matters of common interest with a wide circle of friends. On such occasions he could always be found at the center of a lively discussion group. He kept in close touch with his family and friends at a distance by correspondence and looked forward with an avid longing to each visit of the postman.

Van Maanen loved the society of young people. For years he lived at the Y.M.C.A. building and took some part in the activities there. His interest in youth led him to start a fund to provide financial assistance to promising students. The fund was later incorporated and has aided 185 students in completing their education. This fund was successful beyond his fondest dreams. Not a single student defaulted in his repayment and the available capital was gradually enhanced to a considerable total by the contributions of friends and former beneficiaries.

Although he could not carry a tune, van Maanen enjoyed good music and served for many years on the Board of Directors of the Coleman Chamber Music Concerts in Pasadena.

Dr. van Maanen is survived by two sisters and a brother in Holland.

Mt. Wilson Observatory, Pasadena, California, February, 1946.

The Origin of Ursa Major

By GEORGE A. DAVIS, JR.

A murderer seldom invites witnesses to his crime. Convictions for murder are generally obtained on purely circumstantial evidence. The analogy with Ursa Major lies simply in the fact that we have no direct evidence of its origin, and any attempt to prove how, when, and where the constellation was given the name of Bear must depend on indirect evidence alone. Such evidence, however, may prove, "beyond a reasonable doubt," the origin of the constellation; and I shall attempt such proof in this paper. The question has been discussed by many scholars, and some very remarkable answers have been given, from "disease of language" to the personal characteristics of bears themselves!

In spite of assertions on the part of practically all writers on the constellations that the Bear originated in ancient Babylonia, this is definitely not true, for the constellation among the Sumerians, Akkadians, Babylonians, and Assyrians[1] was called MUL MAR-GID-DA, "the constellation of the long chariot."

It is well recognized that the Egyptians[2] did not have a Bear constellation, and that they called our Big Dipper *Khepesh,* "the thigh" or "the ox-leg," and *Mesekhti* or *Meskheti,* "the bull" or "the striker."

The names of Ursa Major among the Chinese[3] (*Pih Tow,* "the northern bushel"), the Arabs[4] (*Banat an-Na'sh al-Kubra,* "the daughters of the greater bier") and the Persians[5] (*Haptoiringa,* "the seven thrones") should be well known by this time and do not refer to an animal of any kind. Although the Teutonic and other northern nations, both in Europe and Asia, made much of the bear in myth and legend, and perhaps in cult, they never used it as the name of the constellation. It was generally known as a wagon or wain of some kind.[6] I have omitted all references to Ursa Major which we find among the pre-Columbian peoples of North and South America and the islands of the Pacific, as I do not consider them relevant to this discussion.

And so, by a process of elimination, we arrive at the conclusion that our constellation was originally called the Bear either by the Hindus or the Greeks. Homer[7] knew our Big Dipper as both *arktos* and *hamaxa,* "the bear" and "the chariot or wain." This, by the way, is the earliest reference to the constellation of the Bear. It is perfectly obvious that the designation "chariot or wain" is Sumerian in origin; but whence the Bear? And here our path becomes somewhat difficult because, like the ancient road to Athens traversed by Theseus, there are obstacles to overcome, for several scholars of Aryan languages and myths have developed a theory which has seemed to some to be the correct answer to our question, holding that the title originated in prehistoric times

among the Indo-Europeans. The argument, very briefly, may be stated as follows:

F. Max Müller,[8] in introducing the subject, says "whenever any word, that was at first used metaphorically, is used without a clear conception of the steps that led from its original to its metaphorical meaning, there is danger of mythology; whenever those steps are forgotten and artificial steps put in their places, we have mythology, or, if I may say so, we have diseased language, whether that language refers to religious or secular interests."

He then goes on to illustrate this "disease of language" by the origin of the Bear constellation among the Greeks and Romans. He utilizes the Sanskrit root *rik*, meaning "to be bright or shining," and says that from it "it was possible to form a derivative *rikta*, in the sense of lighted up or bright." He says that this form does not exist in Sanskrit but that "we may recognize in *riksha* the same derivative of *rik*. Riksha, in the sense of bright, has become the name of the bear, though it is difficult to say for what reason, whether from his bright eyes or from his brilliant tawny fur. The same name was given in Sanskrit to the stars, the bright ones."

There is a passage in the *Rig-Veda* (I. 24. 10) where the word appears, and he translates it "these stars," not "these bears," and he then reminds us that "apparently without rhyme or reason, the same constellation is called by the Greeks and Romans the Bear, in the singular, *arktos* and *ursa*. There may be some similarity between that constellation and a waggon or wain, but there is hardly any to a bear. . . The etymological meaning of *riksha*, as simply the bright stars, was forgotten, the popular meaning of *riksha*, bear, was known to everybody. And thus it happened that when the Greeks had left their central home and settled in Europe, they retained the name of *arktos* for the same unchanging stars, but not knowing why these stars had originally received that name, they ceased to speak of them as *arktoi*, or many bears, and spoke of them as the Bear, the Great Bear, adding a bearward, the Arcturus (*ouros*, ward), and in time even a Little Bear." And he concludes the discussion as follows:

"Thus the name of the Arctic regions rests on a misunderstanding of a name thousands of years ago in Central Asia; and the surprise with which many a thoughtful observer has looked at these seven bright stars, wondering why they were ever called the Bear, is removed by a reference to the early annals of human speech."[9]

Several answers to this line of thought are obvious. There is not the slightest evidence that the Hindus, or anyone else, including the Greeks, ever called the seven brightest stars in Ursa Major "the bears" or "the seven bears," and it will be noticed that Müller himself, in the passage quoted above, translates the word as "stars." The only reference that I have been able to find to the name of the constellation before it became

known as *Sapta Rishayah*, "The Seven Rishis," is in the *Shatapatha-Brahmana* (II. 1. 2. 4), where, in the discussion of the establishment of the sacred fires, it is said that originally the Krittikas, *i.e.*, the Pleiades, were the wives of the *rikshas*, "for the seven Rishis were in former times called the bright ones." I submit that, even in ancient India, the idea of women marrying bears did not enter into the religious consciousness of the Hindus.

The other answer comes from a knowledge of star and constellation names used by peoples all over the world. I can do no better in this connection than quote a passage from Andrew Lang,[10] who reduces the argument to an absurdity. This answer to Müller has never been given in any work on the constellations, and, therefore, I quote it substantially in its entirety.

He first says that Müller's theory is a very good example of the philological way of explaining a myth, and that it might be true in some isolated case. He then goes on to say: "But the explanation does not look so well if we examine, not only the Aryan, but all the known myths and names of the Bear and the other stars. Now, if the philologists wish to persuade us that it was decaying and half-forgotten language which caused men to give the names of animals to the stars, they must prove their case on an immense collection of instances—on Iowa, Kaneka, Murri, Maori, Brazilian, Peruvian, Mexican, Egyptian, Eskimo, instances. It would be the most amazing coincidence in the world if forgetfulness of the meaning of their own speech compelled tribes of every tongue and race to recognize men and beasts, cranes, cockatoos, serpents, monkeys, bears, etc., in the heavens. How came the misunderstood words always to be misunderstood in the same way? Does the philological explanation account for the enormous majority of the phenomena? If it fails, we may at least doubt whether it solves the one isolated case of the Great Bear among the Greeks and Romans. It must be observed that the philological explanation of Mr. Müller does not clear up the Arkadian story of their own descent from a she-bear who is now a star. Yet similar stories of the descent of tribes from animals are so widespread that it would be difficult to name the race or the quarter of the globe where they are not found. Are they all derived from misunderstood words meaning "bright"? . . . We shall often find, if we take a wide view, that the philological explanation which seemed plausible in a single case is hopelessly narrow when applied to a large collection of parallel cases in languages of various families."

I need hardly add that the English language itself contains a multitude of words which have two or more different and distinct meanings; and, furthermore, we understand that this is so, and recognize the fact that this is a phenomenon of all languages, and is not to be explained by disease, ignorance, or forgetfulness.

Being still in ancient Greece, without the intervention or the kind assistance of the Hindus, do we find anything in history, myth, or cult which will help us solve our problem? I believe that the answer lies in the story of Callisto. Briefly, it is as follows:

Callisto ("the fairest") was either a nymph or the daughter of Lycaon, king of Arcadia. She was a friend and companion of Artemis and took a vow to remain a virgin. Zeus, however, loved her, and when Artemis discovered that she was pregnant, she drove her away. Zeus immediately transformed her into a bear to enable her to escape the jealous wrath of Hera. One tradition, however, has it that Hera induced Artemis to shoot her down. Others say that Artemis killed her because she failed to keep her maidenhood. Again we are told that after Callisto's son, Arcas, was born, the ancestor of the Arcadians, Hera herself changed here into a she-bear, and, thereafter, for fifteen years she wandered in the mountains in that shape. Then her son met her while out hunting and would have killed her with his spear had not Zeus immediately transported them both to the heavens where they became the constellations Ursa Major and Boötes. In the oldest known version Hera plays no part and Artemis changes Callisto into a bear by way of punishment, and the reason why Arcas pursued her was that she had ventured into the sacred enclosure of Zeus Lycaeus, into which any creature that entered had to be put to death. There are other variants of the story mentioned by Apollodorus; but the point to remember is that in all of them Callisto is turned into a bear which, sooner or later, is placed in the sky by Zeus as our Ursa Major.[11]

In considering this myth of Callisto, which I hold to be the true origin of the constellation of the Bear, several matters have to be kept in mind. In the first place, it is conceded by classical scholars that Artemis, with whom Callisto is equated in this story, as I shall show presently, was not originally a Greek goddess; she has not even a Greek name, and her worship is very ancient.

Secondly, the Arcadians claim to have come into existence before the creation of the Moon,[12] and they have always regarded Ursa Major as Callisto transformed into a bear by Zeus. It is true that Homer does not directly mention the myth of Callisto, but his statement that the Bear "alone hath no part in the baths of Ocean," may refer to the granting of the request made by Hera to Oceanus and Tēthys that the constellation be prohibited from setting like most of the other stars. It is clear, however, that he has little respect for Artemis anyway, as she is a goddess of the conquered race. The Greeks adopted the myth as they adopted Artemis herself; and Hesiod is perfectly familiar with the story, according to Eratosthenes.

Thirdly, it is well known that every Greek race attempted to trace its origin to Zeus. Arcas was the ancestor of the Arcadians, and it would be highly desirable if he could have for his mother their favorite god-

dess, Artemis. But even at that early date, at least among the Arcadians, she was regarded as a virgin goddess, and hence could not be a mother. One of her cult titles, however, was Calliste, ("the most beautiful"), which could be easily worked over into Callisto, and the original identity of Callisto with Artemis, both as maiden and as bear, is highly probable, especially since the bear, in Arcadia, was an animal sacred to the goddess, and played a prominent part in her cult. Callisto, therefore, and not the goddess herself, became the mother of Arcas by Zeus.[12] The rest of the story furnished the means of placing them both among the stars, Callisto as the Bear, and Arcas as Boötes or *Arktophylax*, "the bear-keeper." The identification of Arcas with Ursa Minor is late and is entirely incorrect.

Lastly, the constellation has always been known as a she-bear, and it is still *Ursa* today.

Although this origin of the name of the constellation has been rather timidly intimated by several writers, astronomical and mythological, no one, to my knowledge, has heretofore attempted to prove such a theory by an elimination of all other possible origins. The evidence, it is true, is indirect, but it appears to me to be conclusive.

REFERENCES

[1] *Cuneiform Inscriptions of Western Asia*, II. xlviii. 56; III. lii. No. 1, Rev. 24; III. lix. No 15, Rev. 7; *Tab.* 81-7-6, 102, l. 13; Ernst F. Weidner, *Handbuch der Babylonischen Astronomie*, 7, 16, 69.

[2] *Book of the Dead*, XVII. 89-92; LXXIV. 2; XCVIII. 2-5; CXLI. 70; *Pyramid Texts*, 458; Sir E. A. Wallis Budge, *The Gods of the Egyptians*, II. 250, 312; W. Max Müller in *The Mythology of All Races*, XII. 59, 109.

[3] *Yi King*, LV. 2, 4; *Li Ki*, I. 1. v. 1; *Chun Tsew*, VI. 14. 5; *Thai-Shang*, 2.

[4] Schjellerup, *Description des Étoiles Fixes* (*ap.* as-Sufi), 49; Ideler, *Sternnamen* (*ap.* Qazwini), 19; Hyde, *Syntagma* (*ap.* Ulugh Beg), I. 14.

[5] *Sirozah*, I. 13 and II. 13; *Rashn Yasht*, 28; *Farvardin Yasht*, 60; *Tir Yasht*, 12; *Dina-i Mainog-i Khirad*, XLIX. 15-21; *Bundahish*, II. 7.

[6] See Jacob Grimm, *Teutonic Mythology*, I. 151, II. 724-726, London, 1880; and consult also Uno Holmberg in *The Mythology of All Races*, IV. 417, 425-428.

[7] *Iliad*, XVIII. 487; *Odyssey*, V. 273.

[8] *The Science of Language*, II. 456, N. Y., 1891.

[9] *Ibid.*, 459-462. See also Sir George W. Cox, *An Introduction to the Science of Comparative Mythology and Folklore*, 10-13, London, 1881.

[10] *Custom and Myth*, 141-142, London, 1884.

[11] See Pseudo-Eratosthenes, *Catasterismi*, 1, 2, 8; Pausanias, I. 25. 1, VIII. 3. 6; Hyginus, *Fabulae*, 155, 176, 177, 224, *Astronomica*, II. 1, 4; Apollodorus, III. 8. 2; Ovid, *Metamorphoses*, II. 409-531, *Fasti*, II. 153-192; Scholiast on *Iliad*, XVIII. 487; Servius on Virgil, *Georgics*, I. 138; Scholiast on Germanicus, *Aratea*, 25.

[12] See Apollonius Rhodius, IV. 264; Lycophron, 482; Ovid, *Fasti*, I. 469, II. 290, and V. 90.

[13] *Cf.* Müller, *ibid.*, II. 737.

Planets and Stars from Dark to Daylight

By H. B. RUMRILL

If poetic incentive were needed for this sort of star-gazing it might be sought in the fine opening of Henry Kirk White's "Lines Written on a Survey of the Heavens, in the morning before daybreak":

> *Ye many twinkling stars, who yet do hold*
> *Your brilliant places in the sable vault*
> *Of night's dominions!*

During the previous morning apparition of the planet Venus, in the fall and winter of 1943, I found the phase development interesting to watch from dark into full daylight. In the fairly dark sky that precedes dawn my observations were made with the help of the Herschel helioscope, *minus screen glass*—an invaluable accessory since the prism rejects the excess light or irradiation which is such an effective barrier to sharp definition.

With slowly increasing daylight in the quiet atmosphere of early morning the outline of the planet becomes gradually plainer and is beautifully clear and distinct until sunshine nearly overpowers its light —itself reflected sunshine. After the sky brightened I removed the helioscope, using the eyepieces alone for viewing directly, because daylight performs the same office. In either way the aureola that surrounds Venus simply disappears, being largely an optical phenomenon. However, with no combination of observing conditions and magnifying power (expanded on occasion by a negative amplifier to as high as 360 and 450) have I been able to discern surface detail, especially variations in the light and shade of its cloudy envelope, with the exception of the slight darkening along the terminator as seen late in the winter of 1944-45.

After clamping the telescope I have frequently returned at short intervals, restoring the position of the image by the motion in Right Ascension, as my mounting lacks clockwork. On a number of mornings I have followed the planet in this way for three or four hours, or until its light became too diffuse for an entirely satisfactory view. Sometimes I have left the telescope for as long and succeeded in relocating it in the same manner, generally with a low power or in the finder.

More recently I have proven the value of this method (better without the helioscope) in the study of Jupiter and Saturn as "morning stars," although their light becomes quite dilute within, say, a couple of hours after sunrise. The satellites of Jupiter vanish before the belt details fade out, the latter not remaining conspicuous, though, after the cessation of twilight. With either of these planets magnifying power should be lessened as the sky brightens. It is when the contrast of

planetary light against the background of sky becomes somewhat softened by the elimination of glare that the eye seems to be most sensitive to delicate detail. This may be regarded as an element of good "seeing," and well worth an observer's attention.

Both Jupiter and Saturn take on a ghostlike appearance with the approach of full daylight, the same as exhibited in a daylight occultation like that of the former in the afternoon of April 30, 1944. This is a similar phenomenon to what is seen of the thin, shortened crescent of the Moon before it passes the Sun on the way to the "new" phase, an observation I have frequently attempted, often without success, particularly when the period before New Moon was less than eighteen hours, as in the morning of October 16, 1944. In exploring the eastern sky for a look at the waning crescent it is my practice to use a long inverting binocular having a power of 15, described in the June, 1940, issue of the *Publications of the Astronomical Society of the Pacific,* the employment of both eyes being a decided advantage.

Extending this kind of observation to the stars provided many instructive experiences. Of course, the more brilliant the star the longer it may be held in the telescope as day advances. The brightest of all—Sirius—was a fascinating sight during the autumn of 1944, but obstructions nearby were a hindrance, preventing a conclusive test toward its setting. The scintillation disappeared slowly and it still remained a bright point of light when my observations ended. Procyon, being higher in the sky, afforded longer time, and even when a mere point of declining light was a fine object. In each case the distance from the place of sunrise was an aid in keeping the star within the field of the eyepiece. (It might be added that the wedge prism, without shade glass, assists in viewing the brightest stars in a dark sky, for the reason given above, its utility gaining with enlargement of aperture.)

Other stars thus observed were Spica, Regulus, Arcturus, Vega, Arided (which name I prefer because of superfluous "Denebs" in the sky), Altair, and Polaris, the latter naturally requiring very little "following"—an advantage almost equivalent to clockwork movement of the telescope when studying decrease of its light with the growth of daylight. Apparently as another consequence of diminution of light, there is less of distinctive star color as compared with the hues visible at night. With the abatement of diffraction phenomena and atmospheric coruscation, the stars gradually assume the character of theoretical points of light, much more pronounced than in a dark sky, and attesting in this way the excellence of the object glass. As with Jupiter's satellites, stars of lower magnitudes, in the same field as a brilliant star, remain visible in a brightening sky in varying degrees, but disappear long before those of first and second magnitudes grow dim.

It was a year or two after making these observations that I learned from Humboldt's "Cosmos" that "the idea of observing the stars by

daylight with a telescope first occurred to Morin, who with Gascoigne (about 1638, before Picard and Auzout) combined instruments of measurement with the telescope." Humboldt quotes from Delambre's "History of Modern Astronomy," that it was "the simple idea that Arcturus and other fixed stars might, like Venus, when once they had been fixed in the field of the telescope before sunrise, be followed through the heavens, after the sun had risen, that led him to a discovery which might prove of importance for the determination of longitude at sea;" stating that no one before Morin was able to distinguish the fixed stars in the presence of the sun, and refers to the ninth magnitude companion of the pole star as having been seen by day in the Dorpat refractor by Struve and Wrangel, and once by Encke and Argelander.

During the recent apparition of Venus I have occasionally followed the planet into full daylight, unfavorable weather preventing extended observation, and one morning, after unclamping the telescope in order to look at the Sun, restored Venus to the field of view by means of the position circles, when it was quite evident that it could have been held in sight throughout the day. This, with a power of 150.

Having once seen the Hercules cluster M. 13, in the early evening twilight through the 60-inch reflector at Mount Wilson (something not to be forgotten), in August, 1939, and having easily resolved the "double-double" Epsilon Lyrae with my own telescope in twilight, it was profitable to mark the length of time during which certain double stars remained clearly such in these observations. Those examined in this way included Castor, Gamma Leonis, and Gamma Virginis, their components equal or not much differing in magnitude, and all seeming to improve in definition with a little lightening of their sky background. All three require powers of about 100 to 150 to be sufficiently separated under the conditions chosen.

The 7th magnitude component of Beta Cygni could not be held in sight with power 60 nearly as long as the principal star of 3½ magnitude, due in part to its darker color; both disappeared within a half hour after sunrise, being within quadrature to the Sun. In the case of 61 Cygni disappearance took place rapidly, with some difference of time between the 6th and 5½ magnitude components—this shortly before sunrise.

In the final stages of daylight illumination it is very easy to lose either planets or stars when the field becomes too bright, or when they are too near the Sun, often tasking one's eyesight to the limit, although doubtless larger apertures than my four-inch would be more appropriate in these telescopic recreations.

The reduction of extraneous light in the field of the eyepiece may be effected either at the object glass or close to the eyepiece itself. If at the object glass, however, separating power is also reduced, and I think

the better method is to limit the volume of light by means of a stop in front of the eyepiece. In pursuing these investigations I sometimes use an iris diaphragm adapted from a photographic shutter and actuated by a movable ring. This gives an admirable adjustment of the amount of light entering the eyepiece, with response in the sensitiveness of the retina, and while it narrows the field of view this is also easily controlled by the iris ring. The result is that the object is seen to better purpose when the eye is confronted with diminished sky brilliancy. Delicacy of adjustment, it is needless to say, is an important factor in observing planets and stars in dark-to-daylight studies. The inclusion in my equipment of an objective iris diaphragm makes possible dual control of the amount of light reaching the eye, permitting a wide range of experiment in this class of visual work.

A perfectly dark sky is practically non-existent, for in a moonless night the stars yield a very sensible amount of illumination, depending upon locality and atmospheric absorption. A brilliant constellation, especially near the zenith, gives a perceptible quantity of light, and the total amount of light with the stars at their brightest (as augmented by the zodiacal light and that from permanent auroral sources) makes a strong contrast with the enhanced darkness of a thick cloud canopy—the Moon absent—when it may be quite hazardous to walk along an unlighted highway.

With the growth of dawn the gradual disappearance of the fainter stars in the telescope is very similar to the effect of moonlight on stars below the third magnitude as seen by the unassisted eyes. Full moonlight, it is well known, makes constellation study almost impossible, although it is a vanishingly small quantity as compared with full daylight, nearly half a million times as great. Momentarily the light at the beginning of dawn is equal to full moonlight, but the comparison time is so short that it soon becomes increasingly difficult to make out star groupings as they speedily disappear in the gathering solar light. This has possibly never been better expressed than by the Persian poet-astronomer of the eleventh century (as originally translated by Fitz-Gerald):

Awake! for Morning in the Bowl of Night
Has flung the Stone that puts the Stars to Flight.

Even the comparatively small volume of reflected light from the Moon when but a few days from new suffices to engulf the outliers of the Orion nebula, as during the early evening of March 18, 1944, both at about the same altitude and not many degrees of arc apart.

The foregoing merely presents additional evidence of the perceptibility of planets and stars in daylight, affected to some extent by individuality in eyesight. I have in mind the visibilty of Venus without a telescope, when approaching and receding from inferior conjunction, requiring that the eyes be accurately directed and focussed; also day

observations of Mercury and Venus through powerful telescopes. Dr. Thomas Dick's "The Practical Astronomer" gives a concise account of such observations (pages 464-490 of the original edition, published in London a hundred years ago). This painstaking old astronomer employed a number of small telescopes for the purpose, experimenting with various powers and apertures, and the story of his work along this line is most entertaining. We can even yet learn something from the old observers! He set an example of thoroughness worthy of emulation and deduced the following conclusions from his observations of Venus.

1. That this planet may be seen distinctly, with a moderate degree of magnifying power, *at the moment of its superior conjunction with the sun,* when its geocentric latitude, either north or south, at the time of conjunction, is not less than 1° 14′, or, when the planet is about 58′ from the sun's limb.

2. That during the space of 583 days, or about 19 months—the time this planet takes in moving from one conjunction with the sun to a like conjunction again—when its latitude at the time of its superior conjunction exceeds 1° 14′, it may be seen with an equatorial telescope every clear day without interruption, except about the period of its *inferior* conjunction, when its dark hemisphere is turned towards the earth, and a short time before and after it. When its geocentric latitude is less than 1° 14′, it will be hid only about four days before, and the same time after its superior conjunction. During the same period it will be invisible to the naked-eye, and consequently no observations can be made upon it with a common telescope, for nearly six months, and sometimes more, according as its declination is north or south, namely about two or three months before, and the same time after its superior conjunction, except where there is a very free and unconfined horizon. In regard to the time in which this planet can be hid about the period of its *inferior* conjunction, I have ascertained from observation, that it can never be hid longer than during a space of 2 days 22 hours; having seen Venus, about noon, like a fine slender crescent, only 35 hours after she had passed the point of her inferior conjunction; and in a late instance when little more than a day from the period of conjunction. The longest time, therefore, that this planet can be hid from view during a period of 583 days, is only about 10 days; and when its latitude at the time of the superior conjunction equals or exceeds 1° 14′, it can be hid little more than two days. This is a circumstance which cannot be affirmed of any other celestial body, the sun only excepted.

3. That every variation of the phases of this planet—from a slender crescent to a full enlightened hemisphere—may, on every clear day, be conveniently exhibited by means of the equatorial telescope. For, if the phase which Venus should exhibit at any particular time be known, the equatorial telescope may be directed to the planet, and its actual phase in the heavens be immediately exhibited.

4. Since it is only at the period of the superior conjunction that this planet presents a full enlightened hemisphere, and since it is only when this phase is presented that both its diameters can be measured—it is of some importance that observations be made on it at the moment of conjunction, by means of powerful telescopes furnished with micrometers.

5. That a moderate diminution of the aperture of the object glass of the telescope is useful, and even necessary in viewing this planet when near the sun. Its effect is owing in part to the direct solar rays being thereby more effectively

excluded; for when these rays enter directly into the tube of the telescope, it is very difficult, and almost impossible to perceive this planet, or any other celestial body when in the vicinity of the sun.

Dick's stellar observations in daylight are equally interesting. He records that

> August 23, 1813, at $0^h\ 12^m$ P.M., saw the star Capella, or α Aurigae, with a power of 60, and immediately afterwards with a power of 30; the aperture undiminished. With this last power it appeared extremely distinct, but not so brilliant and splendid as with the former power. Having diminished the aperture to 9/10 of an inch, it appeared on a darker ground, though in the former case it was equally perceptible. A few minutes afterwards, could distinguish it with a power of 15, the aperture being contracted to half an inch. It appeared very small; it was with difficulty the eye could fix upon it in the field of the telescope; but when it was once perceived, its motion across the field of view could be readily followed. It could not be perceived when the diminished aperture was removed. The sun was then shining in meridian splendour.

He also states that the star Arcturus is easily distinguishable at any time of the day with a power of 30. My copy of this still interesting book contains a marginal notation by a former owner, that "the double star Castor can be seen as easily by daylight as in the darkest night"—an assertion to be taken probably with the proverbial "grain of salt," at least as regards very small telescopes.

From these and several hundreds of similar observations Dr. Dick deduced:

1. That a magnifying power of 30 times is sufficient for distinguishing a fixed star of the first magnitude, even at noon-day, at any season of the year; provided it have a moderate degree of elevation above the horizon, and be not within 30° or 40° of the sun's body. Also, that, by a magnifying power of 15, a star of this class may be distinguished, when the sun is not above an hour and a half above the horizon. But, in every case, higher powers are to be preferred. Powers of 45 or 60, particularly the last, were found to answer best in most cases, as with such powers the eye could fix on the star with ease, as soon as it entered the field of the telescope.

2. That most of the stars of the second magnitude may be seen with a power of 60, when the sun is not much more than two hours above the horizon; and, at any time of the day, the brightest stars of this class may be seen with a power of 100, when the sky is serene, and the star not too near the quarter in which the sun appears.

3. That, in every instance, an increase of magnifying power has the principal effect in rendering a star easily perceptible. That diminution of aperture, in most cases, produces a very slight effect; in some cases, none at all; and, when the aperture is contracted beyond a certain limit, it produces a hurtful effect. The cases in which a moderate contraction is useful, are the two following: (1) When the star appears in a bright part of the sky, not far from the quarter in which the sun appears. (2) When an object glass of a large aperture, and a small degree of magnifying power is used.

Dr. Dick was evidently actuated by an intense desire to learn, at first hand, through purely empirical methods. That little observatory atop his dwelling at "Broughty Ferry, near Dundee," with its old-fashioned instruments and appliances, has, it must be confessed, long been an inspiration to the writer in these and other astronomical pursuits, and it is a pleasant memory how highly my dear old friend, "Uncle John" Brashear, spoke of the work accomplished there, himself an exemplar of enthusiasm and experimental philosophy. The remarks to be found here and there in Dr. Dick's engaging chapters were often forward-looking, and it might be truthfully conjectured that if he were living in the present age of astronomical progress he would be foremost among observers of the heavens.

TREDYFFRIN OBSERVATORY, BERWYN, PENNSYLVANIA, OCTOBER, 1945.

The Names of the Satellites

By SAMUEL G. BARTON

I have recently investigated the sources of the names of the satellites and the search leads me to believe that it will be of interest to others to have the scattered material collected. Some of it is in rather inaccessible places. I have no knowledge that this has ever been done. The material is arranged in order of increasing distances of the planets from the Sun, although from some points of view the order of discovery would be more logical.

The Moon is unique in that, at least until the time of Copernicus, it, like the Sun, was regarded generally as a planet. No satellites, as such, were known. Our name, the Moon, comes to us through the Anglo-Saxon. In this it is like the name, the Sun, but not like those of the planets, which, excepting the Earth, come from Roman mythology.

The satellites of Mars were discovered by Asaph Hall, at Washington, D. C., in 1877. By right of discovery, he named them. The story as told by him,[1] is:

"Of the various names that have been proposed for these satellites, I have chosen those suggested by Mr. Madan of Eton, England, viz:

DEIMOS for the outer satellite;
PHOBOS for the inner satellite.

"These are generally the names of the horses that drew the chariot of Mars; but in the lines referred to they are personified by Homer, and mean the attendants, or sons of Mars. These lines occur in the Fifteenth Book of the Iliad, where Ares is preparing to descend to the earth to avenge the death of his son. Bryant's translation is as follows:

He spake, and summoned Fear and Flight to yoke
His steeds, and put his glorious armor on."

These lines explain why the names are cited in some places as those of horses and in others as those of gods. Liddell and Scott's Greek Lexicon explains that in Homer, phobos means flight, properly, the outward show of fear, as opposed to deos (poetic deimos), the sensation of fear.

The existence of satellites of Jupiter was first made known with the announcement of the discovery of four, by Galileo, in 1610. To distinguish them from the far fainter satellites since discovered, these four are known as the Galilean satellites. This title, a most natural one, was probably first applied by W. T. Lynn.[2] After a discussion of memorials and of the transitory character of human monuments, Galileo, in the introduction to his "Sidereus Nuncius," writes:[3]

"Wherefore the fame of Jupiter, Mars, Mercury, Hercules, and the rest of the heroes by whose names stars are called, will not fade until the extinction of the splendour of the constellations themselves . . .

"And so, inasmuch as under your patronage, most Serene Cosmo, I have discovered these stars, which were unknown to all astronomers before me, I have, with very good right determined to designate them with the august name of your family, and as I was the first to investigate them, who can rightly blame me if I give them a name, and call them the Medicean Stars (Medicea Sidera), hoping that as much consideration may accrue to these stars from this title as other stars have brought to other heroes."

The reference is to the "Most Serene Cosmo de'Medici, the second, fourth Grand Duke of Tuscany," who was Galileo's pupil and patron. The memorial has not proven as enduring as Galileo supposed, for, as Bailly comments:[4] "This glorification was not flattery, but only a recognition of a great city, long governed by a beneficent family. The name Medici was already dear to the arts; but the honors most merited are not those most durable. Passing from the hands of Galileo the theory of these stars was cultivated in France and in England, where this name had not the same claim. These planets belong more to Jupiter than to princes of the Earth and they keep the name of his satellites."

But Galileo was not alone in discovering these satellites. Simon Marius, court astronomer of the margraves of Brandenburg, in his work, "Mundus Jovialis" (the world of Jupiter), published in 1614, claims to have discovered them even earlier than Galileo. With the idea of honoring his patrons, similar to that of Galileo, he called the satellites, the Brandenburgian stars (Sidera Brandenburgica).

An extract from a letter, which Galileo received on this occasion from the court of France, will serve to show how highly the honor of giving a name to these new planets was at that time appreciated, and also how much was expected from Galileo's first success in examining the heavens:[5] "The second request, but the most pressing one which I can make to you, is, that you should determine, if you discover any other

fine star, to call it by the name of the great star of France, as well as the most brilliant of all the Earth; and if it seems fit to you, call it rather by his proper name of Henri, than by the family name of Bourbon; thus you will have an opportunity of doing a thing just and due and proper in itself, and at the same time will render yourself and your family rich and powerful forever." The writer then proceeds to enumerate the different claims of Henri IV to this honor, not forgetting that he married into the family of the Medici, etc.

In order to have individual names for the satellites, Marius suggests that they be called Mercurius Jovialis, Venus Jovialis, Jupiter Jovialis, and Saturnus Jovialis, that is, Mercury of Jupiter corresponding to Mercurius Solaris, Mercury of the Sun, etc. Saturnus Jovialis, the outermost satellite would then correspond with Saturn, the outermost planet then known. Mars, he explains, is excluded because of its exceptional color and because the influences attributed to it by astrologers are the opposite of those attributed to Jupiter, which would render its presence inharmonious. No mention is made of the Earth.

Following this discussion Marius continues with words which I quote in the original Latin, as well as in translation, since the original is quite difficult of access. I have used the copy bequeathed to the Franklin Institute by Dr. Gustavus W. Cook.

"Forsitan aute non deerunt, quibus hactenus recensita nomina non placebunt, sed proprium uniuscui usq: horum quatuor Jovialium siderum nomen ab Astronomis flagitabunt. Ijs etiam in hunc modum satisfieri posse puto, quod tamen absque ulla superstitione & cum licentia Theologorum factum volo. Jupiter à poëtis ob illicitos maximè amores arguitur. Inprimis autem celebrantur maximè tres foeminae Virgines, quarum furtive amore Jupiter captus & potitus est, videlicet Io Inachi Amnis filia: Deinde Calisto Lycaonis, & deniq: Europa Agenoris filia: Quin etiam impensius amavit Ganymedem puerum formosum, Trois Regis filium, adeo etiam ut assumptâ aquilaê figurâ, illum humeris impositum, in coelum transportavit, prout fabulantur poetae, inprimis autem Ovidius lib. 10 fab. 6. Itaque non male fecisse videor, si Primus à me vocatur Io Secundus Europa: Tertius ob luminis Majestatem Ganymedes Quartus denique Calisto. Quae nomina sequenti disticho comprehenduntur.

Io, Europa, Ganimedes puer, atque Calisto,
Lascivo nimium perplacuere Jovi.

"Huic figmento & propriorum nominum impositioni occasionem praebuit Dominus Keplerus Caesareus Mathematicus, quando mense octobri Anni 1613, Ratisbonae in Comitijs unâ eramus. Quare si per jocum & per amicitiam inter nos tunc initvm, illum compatrem horum quatuor siderum salutavero, haud male fecero.

"Verum uti haec nomina omnia à me sunt liberè conficta, ita etiam cuique liberum esto, ea vel repudiare vel acceptare."

This passage may be translated as follows:[6] "Perhaps, however, there will be some who will not be satified with the names hitherto applied, but will demand from astronomers a name for these four satellites of Jupiter that will be appropriate to each and every one of them. I think that these persons can actually be satisfied in this respect; however I want the thing done without any superstition and with the sanction of theologians. Jupiter especially is charged by the poets with illicit loves. Especially well known among these are three virgins, whose love Jupiter secretly coveted and obtained, namely: Io, the daughter of the river god Inachus, then Callisto daughter of Lycaon, and finally Europa, the daughter of Agenor. Yet even more ardently did he love the beautiful boy Ganymede, son of the king of Troy, to the extent that, having assumed the form of an eagle, he placed him on his shoulders and transported him to heaven (Olympus) according to the tale told by the poets, especially by Ovid in book 10 fable 6 (of the Metamorphoses). And so I believe I have not done badly in naming the first Io, the second Europa, the third, on account of the splendor of its light, Ganymede, and lastly the fourth Callisto. These names are comprised in the following distich:

> Io, Europa, the boy Ganymede, and likewise Callisto
> aroused to excess the lust of Jove.

"Mr. Kepler, the Imperial Mathematician, presented the opportunity for this fanciful application of names when we were together at a meeting in Ratisbon (Regensburg), in October, 1613. Therefore, if I hail him as the co-sponsor of these four stars as a result of a jocular fantasy and of the friendship begun between us at that time, I shall not have done badly.

"But all of these names have been freely imagined by me, so let everyone feel free either to reject or to accept them."

The article on Ganymede in the "Encyclopaedia Britannica" may well be read in this connection.

In 1623 Galileo[7] denounced the claims of Marius to discovery, accused him of plagiarism, etc. Marius was then suffering from the illness of which he died and was unable to defend himself. His reputation suffered severely from these unjust allegations, widely believed, but in recent years he has had able defenders, notably Oudemans and Bosscha,[8] and there seems little reason to doubt his integrity and ability, or to doubt that he discovered the satellites independently, either earlier than Galileo or at practically the same time.

This controversy had much influence in the naming of Jupiter's satellites. Those who favored Galileo and who thought Marius an imposter declined to use the latter's names lest their use be regarded as a recognition of his claims, and others thought it might at least give him a preference. So to this day the names Io, etc., are little used. No names of this type are used in the *American Ephemeris*. The *British Nautical*

Almanac makes a little use of them.

Galileo, beginning about January, 1611, designated the satellites individually by the numbers one to four (really one to four dots) in order of increasing distance from the planet. This is an impersonal system. Really, because of the many phenomena, occurring with the four bright satellites and needing description (eclipses, occultations, and transits), no other system can compare in simplicity with that of numbering and this has probably been a factor in naming them.

In 1892, after the number system had been in use for centuries, a fifth satellite of Jupiter was discovered by Barnard at the Lick Observatory. In September, 1893, he wrote as to its name:[9] "So far this satellite has not received any name, although many names have been suggested for it. Most of these are mythological and have some connection with Jupiter. Columbia, on account of the satellite being found in the Columbian year, and Eureka, because of California, the state in which it was discovered, have been suggested. It would seem, however, almost to have found itself a name—'The Fifth Satellite.'

"In astronomical literature there is a strong tendency to call it simply 'The Fifth Satellite' as it was called in the announcement of discovery. There is some opposition to this, as it might be misleading. The other satellites of the giant planet, besides their mythological names, are also designated as I, II, III, IV, with the Roman numerals, in the order of their distance from Jupiter. If now the new one is called V it would imply that it is the most distant of the satellites, while in reality it is the nearest of all to the planet, and ought by all means, according to this method of numeration, to be Satellite I, which would necessitate a renumbering of the satellite system. I would say, also, in this connection, that the celebrated French astronomer, Camille Flammarion, has written, suggesting the name Almathea, the nurse of Jupiter (the smallness of the satellite would make this name rather inappropriate), and giving various reasons why it should be so called.

"The most that can be said at present is that it is yet nameless, and may so remain. The mythological names of the four older satellites are seldom used. It may be necessary, however, to give it a mythological name to prevent confusion."

In July, 1894, he wrote:[10] "The numerals, to me at least, stand as names, and do not necessarily have any bearing on the relative distances of the satellites. It would be dangerous and absurd to change the present notation to introduce the new satellite as I, and it would be equally absurd to call it 0, as some have suggested, for we cannot tell what development the great telescopes of the future may bring about in the Jovian satellite-system.

"I think, therefore, that this new moon should continue to be called the 'Fifth Satellite,' or Satellite V, as I have always called it. This will also be correct if we assume the other satellites were numbered in the

order of their discovery, which can be done without violating the facts.

"There is certainly nothing to be gained by giving this object a special mythological name. However, if it is the general desire of astronomers that it should bear such a name, I will select one for it.

"The other satellites of the solar system (except that of Neptune) are suitably named and those names have come into regular use. Why not let the magnificent Jovian system differ from all the rest by a different order of nomenclature."

The year 1892 is called the Columbian year because it marked the 400th anniversary of the discovery of America by Columbus. Eureka, the exclamation of Archimedes, is the motto of the State of California, found on its great seal. W. T. Lynn[11] suggested for the satellite the name Fulmen, the Latin word for thunderbolt, or Keraunos, the Greek equivalent, and discussed names in general. Other names of the nature of those used by Marius come to mind, such as, Dione, Leda, Leto or Latona, Maia, Metis, Mnemosyne, and Semele, all of which, however, have been used as names of asteroids, but then so have Io, Europa, Ganymed, and Kallisto and I think no confusion has been thus created. Dione is also the name of a satellite of Saturn. Almathea is likewise the name of an asteroid. What, indeed, isn't?

The fifth satellite remains otherwise nameless. Barnard's caution as to possible future discoveries has been justified by the discovery of six additional satellites. These are also nameless except as they are known by the numbers VI to XI, applied in the order of discovery. The satellites in the order of increasing distance from Jupiter are V, I, II, III, IV, VI, VII, X, VIII, IX, XI. This list gives additional evidence of the instability of a system of numbering according to distance. Furthermore the distances of satellites VI, VII, and X are nearly equal as is also the case with VIII, IX, and XI. A slight change in the distance of any of these satellites (and the perturbations are large, particularly in the outer group)[12] might change the order of relative distances. In the case of Jupiter precedent has probably deterred discoverers from assigning names to the more recently discovered satellites.

The situation with respect to the satellites of Saturn was somewhat comparable. Huygens discovered the brightest satellite, now known as Titan, in 1655. He called it simply, Luna Saturni, the moon of Saturn. In the dedication to his "Systema Saturnium," written in 1659, he wrote concerning it:[13] "We should rejoice in its capture, for, hitherto lacking one, it now completes the collection of wandering stars and their number twelve. I almost venture to assert that in the future no more will be found. What is certain is that the small planets exist from this time in number equal to that of the large and primary planets, among which must be counted this Earth, and that the two groups together are expressed by the number which we consider as perfect, on the strength of which we could believe that this mode of existence has been pre-

destined by the Supreme Architect."

These remarks were soon rendered absurd by the discovery of a second satellite in 1671, a third in 1672, a fourth and a fifth in 1684, all by G. D. Cassini, who wrote:[14] "The satellites of Saturn, still more grand and more difficult to discover (than the Sydera Medicea of Galileo), are not unworthy of bearing the name of Louis le Grand (Louis XIV), since they have been discovered under the glorious reign of his majesty and because of the extraordinary assistance furnished to astronomers at his observatory at Paris. We may justly call them the Louisian Stars (Sydera Lodoicea)."

This name I understand to include the five known satellites. Proctor,[15] however, restricts it to the four discovered by Cassini. Titan was discovered in Holland, but during the king's reign, and its discoverer, Huygens, enjoyed the king's patronage from 1661 to 1681, living then in Paris.

In order to distinguish the satellites from each other, Cassini denominated them according to their distances from the planet, the innermost being the first satellite. According to this nomenclature, the satellite discovered by Huygens, although first in order of discovery, was designated the fourth satellite.

A sixth and a seventh satellite were discovered by Sir Wm. Herschel in 1789, both closer to the planet than the other five. He designated them as sixth and seventh in order of discovery, the seventh being the closer to the planet. The situation was then a confused one.

This is the story as told by Sir John Herschel:[16] "Considerable confusion used already to prevail before the discovery of this satellite (the eighth), in the nomenclature of the saturnian system owing to the order of discovery not coinciding with that of distances. Astronomers were not agreed whether to call the two interior satellites the sixth and seventh (reckoning inward) and the older ones the 1st, 2d, 3d, 4th, and 5th, reckoning outward; or to commence with the innermost and to reckon outward, from 1 to 7. This confusion, which the introduction of an eighth would have reckoned intolerable, has been obviated by a mythological nomenclature, suggested in a former edition of this work, and which has been generally accepted, in consonance with that at length completely established for the primary planets. Taking the names of the Titanian divinities, the following verses (pardoning false quantities) afford an easy artificial memory.

> Japetus cunctos supra rotat, huncce sequuntur
> Hyperion, Titan, Rhēa, Dionĕ, Tēthys,
> Enceladus, Mimas—

"It is worth remarking that Simon Marius, who disputed the priority of the discovery of Jupiter's satellites with Galileo, proposed for them mythological names, *viz.*, Io, Europa, Ganymede, and Callisto. The revival of these names would savor of a preference of Marius's claim,

which, even if an absolute priority were conceded (which it is not), would still leave Galileo's general claim to the use of the telescope as a means of astronomical discovery intact. But in the case of Jupiter's satellites there exists no confusion to rectify. They are constantly referred to by their numerical designations in every almanac."

This rather lengthy passage merits quotation in full. It requires considerable comment. The translation of the verse is, Japetus revolves outside all the others and this is followed by Hyperion, etc. The pronunciation of Dione and Tethys are not those given by present-day dictionaries in which all the vowels of Dione and the "e" of Tethys are long. One might question the fitness of Enceladus and, to a lesser extent, of Titan.

These lines, written in 1858, are now in some respects obsolete. The defense of Marius has been cited. If Sir John could name eight satellites, none of which he discovered, it does not seem inappropriate to accept the names proposed by Marius, who, at least, shared in the discovery of these satellites. Otherwise we should, perhaps, in fairness, not use the term Galilean satellites, use of which likewise shows a preference. The names Io, etc., are now used to some extent in the *British Nautical Almanac,* and, as already shown, there is now inconsistency, if not confusion, in the designation of Jupiter's satellites by numbers. Should the Marius taboo be kept alive? Should great weight be given Barnard's comments in the light of present altered situation?

Sir John Herschel discards a number system in respect to Saturn's satellites. Others do not wholly. The almanacs number them in order of increasing distance from Saturn, although they make full use of the mythological names. Russell, Dugan, and Stewart, in their "Astronomy," number them, and in the revised edition the satellites of Uranus also, in order of discovery. Any other system, may, of course, be upset by the discovery of additional satellites.

A ninth satellite of Saturn was discovered in 1898. Since this satellite is more distant than the others, its discovery introduced no confusion in numbering. The story of its name is told in the following passage:[17]

"Prof. William H. Pickering, as the discoverer, suggests that the name Phoebe, a sister of Saturn, be given to the new satellite. Three of the satellites, Tethys, Dione, and Rhea, have already been named for Saturn's sisters, and two, Hyperion and Japetus, for his brothers."

Professor Pickering thought that he had discovered a tenth satellite, in 1905, about which he writes as to its name:[18] "A name has been selected from among those of the sisters of Saturn, as in the case of Phoebe, and it has been decided to call the new satellite Themis." This supposed satellite has not been followed by continued observations and its existence is doubted. It is usually not listed among the satellites. It was found to be seventh in order of distance from the planet, and, if

accepted, it would alter the numbers of the outer satellites.

Two of the satellites of Uranus were discovered by Sir Wm. Herschel in 1787. He thought that he had detected several others. In accordance with precedent he assigned them numbers, not names. In 1851, Lassell discovered two additional satellites and showed that only two of Herschel's satellites were real. Confusion was thus created.[19] Lassell avoided the difficulty by naming the satellites. In his words:[20] "In these tables I have for facility of reference employed a nomenclature of the satellites of Uranus proposed at my request by Sir John Herschel and selected by him from fairy mythology. The most distant of the two bright satellites discovered in 1787 by Sir W. Herschel is denominated Oberon, the other Titania, and, pursuing still the order of distance, the inner ones now discovered are Umbriel and Ariel."

Further information is given by Sir John, himself, who wrote:[21] "Proceeding from without, inward in succession, the names Oberon, Titania, Umbriel, and Ariel, of the fairies, sylphs, and gnomes of Shakespeare and Pope have been assigned respectively."

Oberon and Titania are the king and queen of fairies in Shakespeare's "Midsummer Night's Dream." Umbriel is a gnome and Ariel a sylph in Pope's "Rape of the Lock." Ariel is also a male spirit in Shakespeare's "Tempest." The name is also that of a rebel angel in Milton's "Paradise Lost." These satellites are not numbered in the almanacs.

Thus the discoverer, Sir Wm. Herschel, was represented by his son in the naming. There is here the only departure from classical mythology (excepting the Moon), which is a bit strange in view of Sir John's comment in connection with the names of the satellites of Saturn. Sir John, although he discovered no satellites, provided the names for twelve, that is, for all known in his day, excepting the Moon and the four of Jupiter whose names he rejects. The Moon, Deimos, Phobos, and Phoebe are in fact the only satellite names in normal use today not

NAMES AND PRONUNCIATIONS*

Ariel	ā'rĭ-ĕl	Io	ī'ō	Rhea	rē'ȧ
Callisto	kȧ-lĭs'tō	Japetus	jȧp'ē-tŭs	Tethys	tē'thĭs
Deimos	dī'mŏs	Mimas	mī'mȧs	Themis	thē'mĭs
Dione	dī-ō'nē	Moon	mōōn	Titan	tī'tȧn
Enceladus	ĕn-sĕl'ȧ-dŭs	Oberon	ō'bĕr-ŏn	Titania	tĭ-tā'nĭ-ȧ
Europa	ū-rō'pȧ	Phobos	fō'bŏs	Triton	trī'tŏn
Ganymede	gȧn'ĭ-mēd	Phoebe	fē'bē	Umbriel	ŭm'brĭ-ĕl
Hyperion	hī-pēr'ĭ-ŏn				

* For key to pronunciation see Pop. Astr. 50:357

supplied by him. It may be noted that he, and Hall also, name the satellites from without inward, whereas the natural and usual system of numbering is in the reverse order.

Neptune has but one known satellite, discovered by Lassell in 1846. It is ordinarily not given a name. Flammarion writes of it:[22] "The body has not yet received a name. The god Neptune however was not without a son; would not the name Triton, one of the most diligent companions of his father on the ocean, be suitable for it?"

REFERENCES

[1] "The Satellites of Mars," p. 6. Reprinted in "Source Book in Astronomy," Shapley and Howarth, p. 323.
[2] *The Observatory*, **15**, 429.
[3] *The Sidereal Messenger of Galileo Galilei*, translation by E. S. Carlos.
[4] "Histoire de L'astronomie Moderne," **2**, 92.
[5] "Library of Useful Knowledge," Galileo, p. 26. I have been unable to find the original of this letter, even in the twenty-volume edition of Galileo's works and letters. Henry IV was assassinated May 14, 1610.
[6] Translation by my friend Dr. W. W. Blancké.
[7] *Il Saggiatore* p. 2.
[8] *Archives Néerlandaises des Sciences Exactes et Naturelles*, serie II, **8**, 11, *et seq.* and **12**, 258, *et seq.*
[9] *Pop. Astr.*, **1**, 81.
[10] *A. J.*, **14**, 97.
[11] *The Observatory*, **15**, 429.
[12] *Ap. J.*, **100**, 57, *et seq.*
[13] "Oevres Complètes," **15**, 213.
[14] *Mémoires de L'académie des Sciences*, **10**, 494.
[15] "Saturn and its System," p. 57.
[16] "Outlines of Astronomy," p. 460.
[17] *Harvard College Observatory, Circular* 43. Reprinted *Pop. Astr.*, **7**, 235.
[18] *Annals Harvard College Observatory*, 53, No. 9. Reprinted *Pop. Astr.*, **14**, 18.
[19] *Monthly Notices R.A.S.*, **35**, 16, *et seq.*
[20] *Astronomische Nachrichten*, **34**, 326.
[21] "Outlines of Astronomy," p. 461.
[22] "Popular Astronomy," Flammarion-Gore, p. 470.

FLOWER ASTRONOMICAL OBSERVATORY, UNIVERSITY OF PENNSYLVANIA,
NOVEMBER 1, 1945.

The Astronomical Significance of Easter

By KAREL HUJER

What astronomical significance is there in the various observances connected with the Easter festival? One wonders if arbitrary caprice induced the Council of Nicaea in 325 A.D. to fix Easter day on the first Sunday after the full moon following the vernal equinox, or if the church fathers were compelled to incorporate an ineradicable custom of greater antiquity. Whether or not a divergence of views concerning the placement of Easter prompted Constantine to summon the council is of minor importance. It is an established fact that the Easter festival even then was an ancient, spring, sacred observance. Through ages and localities, the date of the festival varied between March 15 approxi-

mately and the end of April. The English word *Easter* is distinctly derived from the Anglo-Saxon goddess of spring, Ostara; in the Saxon language the month of April had the name of Oestur-monath.

There exists a series of peculiar Easter ceremonies in old European churches and among the country folk. Most interesting is the extinguishing of the so-called eternal light in the principal altar lamp on the Thursday preceding Easter Sunday. The following Saturday evening the lamp is relighted by the ceremonial building of the fire by means of flying sparks from striking quartz. This ritual, including the solemn procession of the Resurrection, of course is interpreted generally as being in commemoration of Christ. We will examine the custom more closely.

Apart from the usual Christian Easter ceremonies, I found in many European villages an Easter children's play of unusual interest. Its general nature consisted in carrying a straw effigy of death, representing Winter, out of the village, to be placed on a pyre amidst great rejoicing. Frequently an old rhyme was chanted: "We carry death out of the village; may new life awaken in our village!" This particular ceremony was spontaneous among country people, set apart from any church supervision or interference. Both the church and folk ceremonies, however, pointed to the same natural phenomenon, namely, the victory of life over death, the coming of springtime. The general use of Easter eggs is a most characteristic rite of Easter. Painted eggs have been profusely used as the symbol of fecundity and the hope of new life.

An analysis of our Easter rituals, which seemingly purport purely Christian significance, will reveal that similar miraculous events occurred in faiths of civilizations which preceded the Christian era by thousands of years. For example, Dupuis writes[1] that Krishna, the crucified Hindu Savior, rose from the dead. Similar stories circulated about Buddha,[2] the Chinese Lao-Kium,[3] and Zoroaster.[4] Ovid's poem, written at the time of the Roman Emperor Augustus, describes Aesculapius, the Son of God, as being put to death and being resurrected. Likewise, the Savior Adonis or Tammuz, after being put to death, arose from the dead. Julius Firmicius, an eminent early Christian priest and scholar who lived during the reign of Constantine and therefore at the time of the Council of Nicaea (325 A.D.) gives an account of the rites of Adonis. He is struck by the similarity of the heathen mysteries with the Christian sacrament honoring the death and resurrection of Christ Jesus. Alexander Murray quotes the exclamation which the ancient Greeks used during their Easter festival: "Adonis lives and is risen again."[5] In our Christian Easter services the name of Christ replaces Adonis.

Dupuis says: "The obsequies of Adonis were celebrated at Alexandria with utmost display. His image was carried with great solemnity to a tomb, which served the purpose of rendering him last honors. Be-

fore singing his return to life, mournful rites were celebrated in honor of his suffering and his death. The large wound he had received was shown, just as the wound was shown which was made to Christ by the thrust of the spear. The feast of this resurrection was fixed at the 25th of March."[6] Bonwick,[7] Prichard,[8] and other authoritative writers agree that what Adonis was to the ancient Greeks, Osiris, the Egyptian Savior, was to the Egyptians. Osiris, too, was put to death, whence he arose from the dead. The worship of Osiris was universal in Egypt prior to any similar worship in the Mediteranean region.

Therefore, it is historically clear that Christians annually celebrate the resurrection of the Savior in much the same manner as did the pre-Christians who, in their sacred mysteries, commemorated the resurrection of their Saviors. The progress made is that it is brought out of the mysteries and has become a common heritage of all humanity. It is evident that the celebration of this resurrection is symbolic of the return of spring, conditioned by the position of the sun exactly as it crosses the celestial equator, which is on March 21; 2000 years ago this apparently occurred on March 25. In regard to the 25th of March, Cedrenus, a celebrated Byzantine writer, says, as quoted from Dupuis: "The first day of the first month is the first of the month Nisan; it corresponds to the 25th of March of the Romans, and the Phamenot of the Egyptians. On that day Gabriel saluted Mary in order to make her conceive the Savior. I observe that it is the same month Phamenot, that Osiris gave fecundity to Isis, according to Egyptian theology. On the very same day, our God Savior—Christ, Jesus, after the termination of his career, arose from the dead; that is what our forefathers called Pass-over, or the passage of the Lord."[9]

These similarities and analogies, of which only a few are here introduced, are most striking. St. Augustine observes: "The same thing which is now called Christian Religion, existed among the Ancients. They have begun to call Christian, the true religion which existed before." With the lapse of time, as the fame of Jesus of Nazareth grew and spread, the same fateful trend occurred as in preceding cases. Christ was placed in the rôle of previous idolatrous deities, whether this was or was not in accordance with his beautiful and simple teachings. Originally Easter, determined by the full moon, was the great luni-solar festival of resurrection, because the sun-god was annually reborn at the vernal equinox, a point where the sun crossed the celestial equator, made the transit, and designated the period of passover. It is therefore, a very ancient equinoxial holiday, and the question arises whether or not this Spring equinoxial holiday is older than the Winter solstitial festival, our present Christmas. Different authorities hold various opinions on this, and it cannot be held as definitely solved. J. Norman Lockyer, in his work "Dawn of Astronomy," deals with this problem and does not appear to express a final opinion. He makes a careful in-

vestigation of the solstitial and equinoxial temples, indicating: "We have either Temples of Osiris pointing to the sunset at the equinox, or Temples of Isis pointing to the sunrise at the equinox, but in either case built in relation to the Pyramids." But he refers to M. Biot's investigation of Ramesseum, concerning which Biot stated that Ramesseum's inscriptions are not the records of the summer solstice, as in the case of Denderah, but of a spring equinox, and he assigns the date of Ramesseum as 3285 B.C., which would show the existence of the spring festival now known as Easter. Biot further suggested that in all probability one of the mythological figures might be a representation of the intersection of the ecliptic and celestial equator in the constellation Taurus at the date above mentioned. Biot's researches justified an early stated opinion by Dupuis, who suggests that the perpetual reference to the Bull—Taurus—found in ancient Egyptian records and mythologies arose from the fact that this constellation on account of the precession of equinoxes occupied an important position at a critical time in the year, which would indicate a very considerable lapse of time, that is, a date preceding 3000 B.C. "We find in the table at the Ramesseum distinct references to the Bull, the Lion and Scorpion, and it is also clearly indicated that at that time the star Sirius rose heliacally at the beginning of the Nile-rise."[10]

The theory that Easter as the Spring equinoxial festival is a holiday even older than the Winter solstitial holiday may be supported by the fact that to primitive man the passing of winter gloom, the opening of spring leaves and the vivifying power of new life pouring forth on this earth was a most impressive and fascinating experience after long nights in his uninviting, obscure, and humid den, to which he was confined ages ago. In that stage of primitive man's life, he did not take as distinct notice of the Winter Solstice as he did of the actual arrival of springtime, which, in his struggle for life, meant the promise of food after winter's desolation and shortage. In his childlike imagination, he wove a charming and supernatural story around the great and miraculous event. Thus, the very ancient Easter spring festival emerged, ages before the Christian era, and being indestructibly rooted, it was adopted and garbed into a Christian allegory.

While for rational man today the Spring Equinox is a simple, celestial phenomenon, without any particular, mysterious background, ancient man fancied in the vernal, reborn nature a celestial rendezvous of the sun and the moon, and as the ancient Egyptians believed, from this divine parentage Horus or Is-su, the child of Atum was born, and Khunsu, the Prince of Peace. According to the ancients and their mystic interpretation, it is the Mother Moon, goddess of night—the woman arrayed with the sun and with the moon under her feet—that still brings forth her child at Easter. March 25 still remains a holiday in the Roman Catholic calendar, known as Annunciation Day, indicating

its unusual correlation with pre-Christian civilizations. Furthermore, in medieval crucifixions, Christ is constantly accompaned by one or another reproduction of the sun and the crescent moon. It is the same luni-solar conjunction that produced the youthful Khunsu in Egyptian mythology.

Therefore, our calendar rules for the date of the Easter festival continue essentially the same as, for example, in ancient Egypt, and the same full moon which contains Khunsu holding forth the Pig of Easter in the famous Zodiac on the ceiling of the Temple of Denderah in Egypt still determines our Eastertide.

REFERENCES

[1] Dupuis: "Origin of Religious Belief," p. 240.
[2] *Prog. Religious Ideas,* Vol. 1, p. 86.
[3] *Ibid.,* p. 214.
[4] *Ibid.,* p. 258.
[5] A. Murray: "Manual of Mythology," p. 80.
[6] Dupuis: "Origin of Religious Belief," p. 161.
[7] Bonwick: "Egyptian Belief," p. 166.
[8] Prichard: "Egyptian Mythology."
[9] Quoted in Dupuis: "Origin of Religious Belief," p. 244.
[10] Lockyer: "Dawn of Astronomy," p. 143.

Another Chain Reaction

KATHERINE CHAMBERLAIN
Professor of Physics, Wayne University, Detroit

[*To aid in giving the widest dissemination possible to the following very timely and very important paper which appeared in* SCIENCE *for February 8, 1946, we are reprinting it here, with permission granted by the Editor of* SCIENCE. EDITOR.]

Twice in the past thirty years the nations of the world have been placed in situations from which there has been no escape except by war. Now, with the advent of the atomic bomb, the problem of what to do to prevent the recurrence of this takes on an urgency that has never existed before. Time after time we have seen aggressive, organized minorities force large numbers of people to conform to their wishes with disastrous consequences. What the world has never yet seen is an equally well-organized effort on the part of people of good will for constructive purposes.

Professor Smyth's report, *Atomic energy for military purposes,* makes it clear that protection against the destructiveness of the atomic bomb is futile. No countermeasures offer any hope except international agreement by all nations that this instrument shall not be used again for war. The difficulty will be to get the agreement. Moreover, it will take time and meanwhile an international race for atomic bomb supremacy may get started that will leave each country no alternative except to inflict upon its citizens the waste of human and material resources

required to meet this threat. In addition to agreement by the governments of the world, a very extensive program of education will be necessary to insure the support of the governed if enforcement is to be practical.

It is clear that the leaders in the development of the atomic bomb are fully aware of the potentialities of what they have brought into being and are doing everything possible to keep the race for supremacy from starting. On the part of the rest of us scientists, however, two attitudes of mind are quite common, both of which seem to me equally to be regretted. The first of these is represented by deep dismay, coupled with a generally hopeless feeling that there is nothing that we can do about it. The second expresses the conviction that scientists must pursue their unfettered way in quest of truth regardless of consequences and that responsibility rests elsewhere to prevent dire results. Moreover, the vastness of great research teams may confer on many of the individuals who participate an anonymity that robs them of their sense of personal responsibility.

The successful outcome of the recent effort to release atomic energy for destructive purposes represents the most extraordinary example of cooperation under the guidance of talented leadership that the world has ever known. The outstanding success of the enterprise appears to be due primarily to the ability of the leadership coupled with the urgency of war and the possession of unlimited resources. By all odds the most important element was the leadership.

It has been my privilege to see several of the people who have contributed to the development of our knowledge of radioactivity at sufficiently close range to be quite certain that a group less inclined to present the world with this means of destruction would be difficult to imagine. To the very great, physics is still natural philosophy, and the search for truth for its own sake is very common. Heretofore, it has always been the highest compliment that could be paid a scientist that he sought the truth without fear or favor. But, now, a moral dilemma of appalling proportions has been injected into the search. Is love of truth to be paramount, or love of mankind? Is the immediate advantage of one's own country to be the primary consideration or the welfare of the world? Will man be equal to this great responsibility that he must now assume? The idea is not new that he sows the seeds of his own destruction when he seeks to usurp power that transcends his wisdom.

If something analogous to a chain reaction could be set off by the scientists of the world to arouse people generally to an understanding of the necessity for an international agreement, world-wide and implemented with power to enforce its dictates, we might see an aroused and determined public demand the laws that are needed. This is in no sense a proposal that we scientists should become the self-appointed

guardians of civilization. But, as the group that is in the best position to appreciate the disastrous potentialities of atomic energy without adequate control and as one not likely to be carried away by hysteria or panic, we should be able to arouse other people to the realization that nothing else greatly matters if this problem is not solved.

As a first step, it seems appropriate to inquire whether the great laboratories that are likely to be the fountain heads of continued nuclear research cannot make public a statement of policy to reassure people generally that the millions they contemplate spending do not mean more bombs or a blind lack of sense of social responsibility. Anyone who is acquainted with them knows all this perfectly well, but the great majority of people do not know them and will certainly be much more inclined to cooperate if convinced that they are not rather sinister places that should be feared.

The directors and senior research staffs of these laboratories probably do not include more than one hundred persons in the entire world. Moreover, the lines of international communication are at their best in science. Most of these people are personally acquainted with one another, which is an enormous aid to understanding. If they were to publish an agreement that no further investigations involving release of atomic energy for military purposes would be carried on in the laboratories under their jurisdiction, the case against the atomic bomb would have the direct sanction of very exalted authority.

Granting that such an agreement by existing laboratories might result in the attempt to establish others with large government subsidies, these will be nothing but warehouses for apparatus unless they can be staffed by very able scientists. Such scientists are not likely to be attracted by offers, however attractive, that exist only because the established laboratories have decided that certain types of research are not in the public interest. Moreover, without very able scientists to coordinate the work, interpret the results, and keep up morale in these dangerous pursuits, it is very doubtful whether they could function effectively. Actually, it is a fair inference that such control is already under way, but the publication of it might be an enormous aid in achieving understanding.

The objection may be made that it is impossible to separate the constructive and destructive aspects of atomic research. And, yet, this has been done very effectively in the case of electricity. While we rarely want to release its more titanic aspects in our laboratories, control of its tremendous forces is so well understood that the General Electric Company did not hesitate to produce the beautiful spectacle of man-made lightning at the Century of Progress before large crowds.

Neither does the argument seem quite sound that war can now be made so terrible that no country would dare to embark on it with atomic bombs. Fear of consequences has never permanently deterred man

from anything, and panic does strange and dreadful things to the character and judgment even of the best of us. If the atomic bombs are ready and war seems imminent, might not a country that is fundamentally peace loving succumb to the temptation of using them first?

It will mean a lot if society can so order things that it will not need to call upon large numbers of its young men in the atomic age to stand guard over the stratosphere. It will mean even more if it will be possible to stop the spread of fear, suspicion, and hate in the world that a race for atomic bomb supremacy will precipitate.

When scientists confined their attention to things like falling bodies, the origin of species, or the motions of the planets, we could afford to smile over the belief of some of their contemporaries that they were a menace to society. But when we seek to recreate elements that possibly had to disappear by radioactive disintegration before the earth originally could become habitable and to release energy at rates never before experienced by man at distances less than that to the sun, we know that we are setting loose forces that are fearful to contemplate. Freedom to carry on such investigations is accompanied by a very terrible responsibility. Very clearly it must rest on all who contribute in the slightest particular, directly or indirectly, to atomic research. This is a plea that those of us who had no direct part in the development of the bomb help those who had to carry this responsibility.

Scientists have always lost control over their inventions and discoveries as soon as the creative phase was completed.

Can't we act while there is still time?

Can't the leaders in these great laboratories in which nuclear research will be carried on state publicly their opposition to further work on those aspects that need to remain military secrets?

Can't all of us in science enter the atomic age with full realization that scientific freedom must be redefined?

Can't we all make a concerted effort to help to educate people generally regarding atomic energy until the thousands of ourselves become the millions who must be convinced if international agreements are to be permanently enforced?

As evidence of our good faith, can't we get Congress to close those plants at Oak Ridge and at Hanford and keep them closed until plans for the control of their products can be worked out?

Then, can't we go to the rest of the world in the same spirit that has made collaboration in the physical sciences so effective in the past and offer all nations complete cooperation while we work to develop the constructive uses of atomic energy and the federation for world security—together?

The Planets in April, 1946

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time, subtract 5 hours, Central Standard Time 6 hours, etc. The phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac*.

Sun. The sun in its northward motion will change its declination from +4° 13′ to +14° 31′ during this month. It will move eastward from the constellation Pisces into the constellation Aries.

Moon. The phases of the moon will occur as follows:

	d	h
New Moon	April 2	5
First Quarter	8	20
Full Moon	16	11
Last Quarter	24	15

It will be at perigee on April 3 and at apogee on April 19.

Mercury. Mercury will move westward in the sky until April 8 after which it will move eastward during the remainder of the month, at first more slowly than the sun and later more rapidly than the sun. This motion will bring it to a point of greatest elongation west on April 23. It will be near the equator and hence several degrees south of the sun, an unfavorable circumstance for northern observers. On and near this date Mercury will rise a little more than an hour before the sun for observers in latitude 45° north.

Venus. Venus will be east of the sun and moving eastward more rapidly than the sun during April. It will therefore become more conspicuous in the evening sky from day to day. At the end of the month it will set more than an hour after the sun. It will then be a short distance south of the Pleiades group.

Mars. Mars will be in quadrature with the sun, ninety degrees east, on April 19. It will therefore be near the meridian at sunset, and hence favorably situated for observation in the evening hours, throughout the month. It will be roughly midway between the bright stars Procyon and Pollux.

Jupiter. Jupiter will be about seven degrees south of the equator and will be moving slowly retrograde during the month. It will be at opposition on April 13. Jupiter, therefore, will be above the horizon practically all night throughout this period. It will be a short distance north of Spica.

Saturn. Saturn will continue to be in the same general region of the sky as Mars. It will be in the constellation Gemini.

Uranus. Uranus will be rather close to the bright star Aldebaran, and hence in favorable position in the western sky in the evening.

Neptune. Neptune, having passed opposition late in March, will be above the horizon practically all night. It will be about a degree south of the equator in Virgo.

Asteroid Notes

By HUGH S. RICE

The situation for available asteroids for observation has not improved very much yet, but it will do so later in the season. We are continuing here the places for JUNO, which is in central Virgo, headed toward Zeta Virginis. At the end

of March its visual magnitude is about 9.3. We also give the first positions of 7 IRIS which is a faint asteroid just now, magnitude about 10.4, and located in southern Ophiuchus.

EPHEMERIDES OF ASTEROIDS, FOR 0^h U.T.

EQUINOX OF DATE

	JUNO				IRIS		
	α		δ		α		δ
1946	h m		° ′	1946	h m		° ′
Mar. 21	13 54.5		— 2 20	Mar. 31	17 6.9		—25 14
26	13 51.5		— 1 40	Apr. 5	17 7.9		—25 14
31	13 48.1		— 1 1	10	17 8.3		—25 12
Apr. 5	13 44.4		— 0 21	15	17 8.0		—25 9
10	13 40.5		+ 0 18	20	17 7.0		—25 5
15	13 36.6		+ 0 55	25	17 5.3		—24 59
20	13 32.6		+ 1 30				

Hayden Planetarium, American Museum of Natural History, New York, N. Y., February 25, 1946.

Occultation Predictions for April, 1946

(Taken from the *American Ephemeris*)

Date 1946	Star	Mag.	IMMERSION Green-wich C.T.	*a*	*b*	Angle E from N	EMERSION Green-wich C.T.	*a*	*b*	Angle E from N
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′										
Apr. 11	42 Leon	6.1	23 58.5	—1.8	+0.5	98	1 17.4	—1.5	—1.5	314
19	47 Libr	5.9	6 50.9	—0.5	—2.3	172	7 40.5	—3.0	+0.7	239
22	λ Sgtr	2.9	6 29.6	—0.8	+0.1	131	7 41.5	—2.2	+1.2	250
22	CD—25°13170	6.2	7 13.1	—1.9	+1.2	79	8 36.1	—1.9	—0.2	297
27	257 B.Aqar	6.3	9 13.8	—0.7	+1.0	108	10 6.5	—1.0	+2.3	208
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′										
Apr. 10	γ Canc	4.7	6 26.6	—2.3	+0.9	46	5 54.2	+1.1	—4.1	357
11	42 Leon	6.1	23 30.6	—1.1	+0.4	113	0 48.2	—1.7	+0.1	290
22	λ Sgtr	2.9	6 33.8	..	..	179	6 49.4	..	..	204
22	CD—25°13170	6.2	6 45.5	—0.8	+0.8	106	8 3.0	—1.6	+0.9	277
OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′										
Apr. 6	129 H^{4}Taur	5.7	3 58.0	—0.8	—0.9	83	4 59.7	—0.3	—0.9	262
7	BD+23°1007	6.5	4 49.5	—1.0	—0.4	69	5 47.7	—0.1	—1.7	292
7	394 B.Taur	6.1	5 25.5	—0.5	—1.2	94	6 24.5	—0.1	—1.0	267
9	82 Gemi	6.2	6 47.1	—0.2	—2.3	135	7 41.3	—0.6	—0.8	255
10	γ Canc	4.7	4 35.8	—1.9	—1.3	110	5 56.2	—1.3	—1.6	292
12	46 Leon	5.7	5 55.7	—3.4	+1.0	69	6 45.5	+0.1	—4.0	354
19	β Scor	2.9	12 31.3	—2.0	—0.8	84	13 49.8	—1.4	—2.1	307
19	56 B.Scor	5.1	12 31.7	—2.0	—0.8	83	13 49.7	—1.4	—2.1	308
OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′*										
Apr. 7	BD+23°1007	6.5	5 6.3	—0.4	—0.1	60	5 51.9	+0.6	—1.6	303
9	82 Gemi	6.2	6 57.7	+0.2	—1.5	119	7 49.2	+0.2	—0.8	269
10	γ Canc	4.7	5 19.2	—1.3	—1.0	93	6 23.2	—0.2	—2.0	311
11	42 Leon	6.1	23 28.5	—1.2	—1.9	152	0 24.5	—1.7	+2.5	246
19	β Scor	2.9	13 10.1	—1.0	—1.5	103	14 19.4	—0.3	—1.2	276
19	56 B.Scor	5.1	13 10.4	—0.9	—1.4	102	14 19.4	—0.3	—1.2	277
22	CD—25°13170	6.2	6 42.3	+0.2	—1.0	147	7 36.7	—2.1	+2.2	241

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The following paper was written in 1931 and printed by the Hydrographic Office, U. S. Navy. A small number of reprints were distributed from here as Reprint No. 11 of the Flower Observatory. As the number of these was far too limited for our exchange list, and as many requests have come from individuals for copies of this paper, it seems wise to reprint it in Meteor Notes. In this way it can become available to the steadily increasing number of observers who are interested in the subject and will make real use of the methods about to be explained.

METHODS FOR COMPUTING THE HEIGHTS AND PATHS OF FIREBALLS AND METEORS

For many years past mariners have been urged by various government departments and scientific institutions to make and report observations on all bright meteors or fireballs seen by them. A ship's officer, due to the very nature of his work, has unrivaled opportunity for such observations when on watch, without interfering with his regular duties. To stimulate interest in meteoric work, the Hydrographic Bulletin for several years has been publishing such observations, and as a consequence their number is greater and accuracy higher. Further to increase this interest the hydrographer, Rear Admiral W. R. Gherardi, U. S. Navy, has requested the writer to outline some of the methods by which the data secured by observers may be turned to scientific account, particularly in the matter of calculating the heights at which such objects appear and disappear. When these have been determined, it becomes a relatively simple matter to calculate the length of path in our atmosphere and the average velocity, if the duration has been observed. Well-known methods would further yield, with no great amount of calculating, the orbit in space of the body in question. These latter are not, however, taken up here, being beyond the scope of this paper. They may be found in several standard works on astronomy.

We must first state that the minimum of data necessary is observations from at least two ships (or stations) whose latitudes and longitudes are both given, for the time of the body's appearance. For the body itself, the angular coordinates of the point at which it appears and disappears are absolutely necessary. They may be given in either altitudes and bearings (azimuths plus 180°) or right ascensions and declinations. The duration of the body's flight should be estimated. It is much more convenient, though not essential, if the hour and minute when

the body appeared are given in Greenwich Civil Time (G. C. T.), using the general convention that G. C. T. is counted from Greenwich midnight. The above data are those essential for the calculations.

It will aid research into the physical aspects of such bodies if notes are given as to color, apparent size, apparent brightness—these latter two are not the same thing, as the first should be in angular measure, the second by comparison with the light of some heavenly body—duration of the trail or train left, if any, irregularities of motion, changes of brightness, etc. In other words, the more complete the observation the more valuable it will be, as it can then be used for more than one problem.

Some of the methods require the coordinates to be expressed in one system, some in another. For a complete solution, which will give us all the data, we are likely to need the coordinates expressed in both the horizontal and equatorial systems. So we need to know how to turn altitude (h) and azimuth ($a = 180° +$ bearing) into declination (δ) and right ascension (α), or inversely.

This being a problem treated of in all books on spherical astronomy and navigation, we merely write down the formulae without giving their derivations.

[A] Given (h) and (a), required (δ) and (α).

In the equations, ϕ = latitude of observer, and M is an auxiliary angle defined by $m \sin M = \cos h \cos a$, $m \cos M = \sin h$, where m is always a positive abstract quantity.

$$\tan M = \cot h \cos a$$

$$\tan t = \frac{\tan a \sin M}{\cos (\phi - M)}$$

$$\tan \delta = \tan (\phi - M) \cos t$$

and $\alpha = \theta - t$

Check: $\cos \delta \sin t = \cos h \sin a$

[B] Given (α) and (δ), required (h) and (a).

N is defined by $n \sin N = \sin \delta$, $n \cos N = \cos \delta \cos t$

$$t = \theta - \alpha$$

$$\tan N = \frac{\tan \delta}{\cos t}$$

$$\tan a = \frac{\tan t \cos N}{\sin (\phi - N)}$$

$$\cot h = \frac{\tan (\phi - N)}{\cos a}$$

Check: $\cos h \sin a = \cos \delta \sin t$

With this brief introduction to the general subject, we will now develop the first method for deriving heights and length of path.

Let the ship S_1 have the position λ_1 and ϕ_1 at G. C. T. θ.

Let the ship S_2 have the position λ_2 and ϕ_2 at G. C. T. θ.

Let the altitude and azimuth of the point of appearance of the meteor as seen from S_1 be h_1, a_1, and as seen from S_2 be a_2, h_2, the object appearing at G. C. T. θ.

Let the altitude and azimuth of the point of disappearance of the meteor as seen from S_1 be h^1_1, a^1_1, and as seen from S_2 be h^1_2, a^1_2, the G. C. T. still being θ, to the nearest minute.

It must be remembered that for a meteor the most skillful observer is likely to make an error of at least a degree in his estimates or measures of any of the coordinates a, h. Hence if the ships are ½° apart, the problem can be worked out by plane trigonometry with all needed accuracy. This limit can be probably extended to 1° with safety, and even more when the correction for curvature is put in. This latter affects all the altitudes. It should be applied as soon as the lines from S_1 and S_2 to E_1 and B_1, in Figure 1, have been drawn.

Taking a sheet of paper, the positions of the ships are plotted, using a convenient unit equal to 1′ in latitude. To get the average value of 1′ in longitude, it will be necessary to multiply the first unit by $\cos\phi$, where $\phi = \frac{1}{2}(\phi_1 + \phi_2)$. The lines S_1M and NS_2 run from south to north. They should be made to converge by the proper amount to allow for the difference in latitude of the two ships.

Then with a protractor, lay off the two azimuths a_1 and a^1_1 from S_1 and a_2 and a^1_2 from S_2. Where S_1a_1 and S_2a_2 intersect is the point B_1, vertically under the point of appearance; where $S_1a^1_1$ and $S_2a^1_2$ intersect is the point E_1, vertically under the point of disappearance. We then have Figure 1.

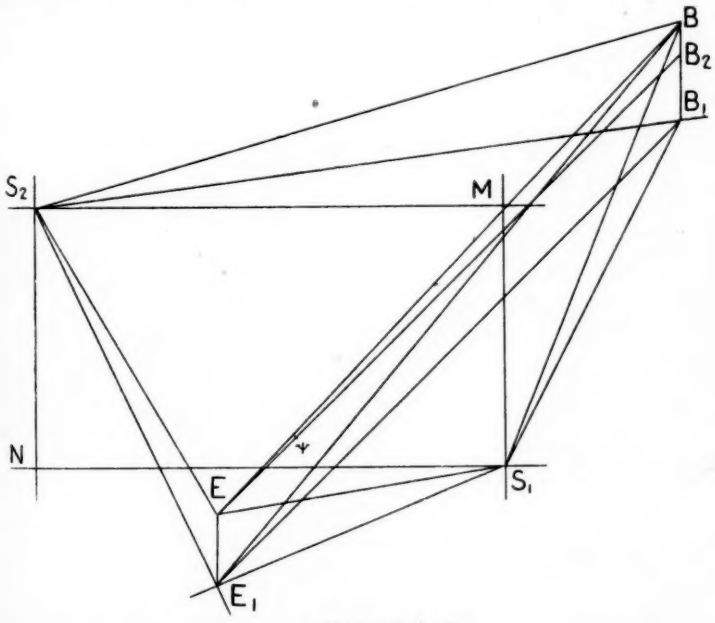


FIGURE 1

B_1E_1 then represents the projected path of the body. Now erect the vertical lines B_1B and E_1E. If the observations are perfect we have

$$\angle B_1S_2B = h_2,\ \angle B_1S_1B = h_1$$

and

$$\angle E_1S_2E = h'_2,\ \angle E_1S_1E = h'_1$$

From our figure we can at once measure off the length of the lines S_1B_1, S_1B_2, S_2B_1, S_2B_2, and B_1E_1. As these are measured in angular units, the corrections to the altitudes will be in order: $\Delta h_1 = \frac{1}{2}\ S_1B$, $\Delta h_2 = \frac{1}{2}\ S_1E$, $\Delta h'_1 = \frac{1}{2}\ S_2B$, $\Delta h'_2 = \frac{1}{2}\ S_2E$.

Let $h_1 + \Delta h_1 = \underline{h_1}$, etc.

We then have $S_1B_1 \tan \underline{h_1} = S_2B_1 \tan \underline{h_2} = B_1B$

$$S_1E_1 \tan \underline{h'_1} = S_2E_1 \tan \underline{h'_2} = E_1E$$

Now draw EB_2 parallel to E_1B_1; then $E_1B_1 = EB_2$ and $B_2B = B_1B - EE_1$.

Then $\tan h_r = \dfrac{B_2B}{EB_2}$, where h_r is the angle of elevation of the apparent radiant of the fireball as seen from E_1. Also draw a north—south line through E_1. Then at once we can measure off the angle between this line and E_1B_1; in other words find the azimuth of the radiant point $= a_r$.

To find the length of path we have

$$\overline{EB}^2 = \overline{B_2B}^2 + \overline{EB_2}^2$$

Then knowing the duration, t, we have the average velocity $v = \dfrac{EB}{t}$

Having h_r and a_r, the coordinates of the radiant, and θ, if desired we can compute δ_r and α_r, and from these the orbit of the body in space.

In practice it is quite certain, however, that one or all of h_1, h_2, h'_1, h'_2 suffer from errors small or large. Hence we will always get two values for B_1B and E_1E. If the angles are not too unequal, and if the observations appear to be of equal weight, the average of the two should give the value to be adopted. If these conditions do not obtain, the computer must use his judgment and weight the observations as best he can.

It is obvious that so far we have assumed the azimuths to be correct and adjusted the altitudes. Sometimes, however, the azimuths show that one or more of the altitudes is in error. Suppose we decide that the $\angle B_1S_2B = h_2$ is the erroneous one. We then, holding the direction of S_1B_1 fixed, run out the point B along the line S_1B until by measurement we find such a point B_1 vertically under B on the line S_2B_1 that

$$\frac{B_1B}{S_2B_1} = \tan h_2$$

As this value of B_1B by construction must fit for h_1, we have solved the problem. The angle MS_2B measured off will as before give the means for finding the computed a_2.

It will be noted that several corrections have been neglected in this method. The reasons are that all the points S_1, S_2, B, and E are assumed to be at no great distance ($< 3°$) apart, and that the inherent errors of observation do not justify the inclusion of small corrections.

Schaeberle's Method

This method, though longer, permits the calculations from paths plotted on a star chart, whose coordinates are thus given in α and δ, without having first to turn these into h and a.

As before we require the latitudes and longitudes of the two ships (or stations) at the moment the meteor appeared, but we now need the local sidereal time at each. From the American Ephemeris and Nautical Almanac we take out the other quantities needed. Then for S_1 let

R_1 = the radius of the Earth at S_1

ϕ_1' = the geocentric latitude at S_1

θ_1 = the sidereal time of observation

and let R_2, ϕ_2', and θ_2 be the corresponding quantities for S_2.

In Figure 2, let the ships be S_1, S_2, and A be the point in which S_1S_2 projected pierces the celestial sphere. Let P be either the beginning or ending point of the meteor, whichever is being calculated. Let S_1P intersect the celestial sphere in R and S_2P in Q; then A, R, and Q lie on a great circle.

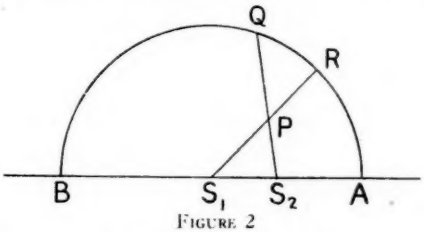


Figure 2

We can then set these equations, referring to Earth's center as origin, its equator as XY plane, with $+X$ directed to the vernal equinox, $+Y$ toward $\alpha = 90°$, $\delta = 0°$; $+Z$ to north pole.

$$(1)\quad \begin{cases} X_1 = R_1 \cos \phi_1' \cos \theta_1 \\ Y_1 = R_1 \cos \phi_1' \sin \theta_1 \\ Z_1 = R_1 \sin \phi_1' \end{cases}$$

$$(2)\quad \begin{cases} X_2 = R_2 \cos \phi_2' \cos \theta_2 \\ Y_2 = R_2 \cos \phi_2' \sin \theta_2 \\ Z_2 = R_2 \sin \phi_2' \end{cases}$$

Now let S_1 become the origin of a new system of axes, parallel to the system just described, and let K be the distance from S_1 to S_2 expressed in fractions of the Earth's equatorial radius. Then

$$(3)\quad \begin{cases} X_3 = X_1 - X_2 = K \cos D \cos A \\ Y_3 = Y_1 - Y_2 = K \cos D \sin A \\ Z_3 = Z_1 - Z_2 = K \sin D \end{cases}$$

Now let the coordinates of A, R, and Q, in right ascension and declination be A_3D_3; $\alpha_1\delta_1$; $\alpha_2\delta_2$. Let I be the inclination of the great circle ARQ to the celestial equator, and N the longitude of one of their intersecting points.

We then have

$$(4)\quad \begin{cases} \tan D_3 = \pm \sin (N - A_3) \tan I \\ \tan \delta_1 = \pm \sin (N - \alpha_1) \tan I \\ \tan \delta_2 = \pm \sin (N - \alpha_2) \tan I \end{cases}$$

and by elimination we get:

(5) $\tan D_3 \sin(\alpha_2 - \alpha_1) - \tan \delta_1 \sin(\alpha_2 - A_3) + \tan \delta_2 \sin(\alpha_1 - A_3) = 0$

If the observations are perfect, this equation is exactly fulfilled. If on the contrary, the three terms do not add up anywhere near zero, the solution may as well be dropped, as the data are too erroneous. Only practice will enable one to decide how much difference from zero in (5) may be permitted and the data still give reasonable solutions.

Now let $\rho_1 = S_1P$ and $\rho_2 = S_2P$. Then the rectangular equatorial coordinates of P referred to the first station as origin will be

$$(6) \quad \begin{cases} x_1 = \rho_1 \cos \delta_1 \cos \alpha_1 \\ y_1 = \rho_1 \cos \delta_1 \sin \alpha_1 \\ z_1 = \rho_1 \sin \delta_1 \end{cases}$$

$$(7) \quad \begin{cases} x_2 = \rho_2 \cos \delta_2 \cos \alpha_2 \\ y_2 = \rho_2 \cos \delta_2 \sin \alpha_2 \\ z_2 = \rho_2 \sin \delta_2 \end{cases}$$

Since the difference between the two sets of coordinates for a given point, as P, must equal the differences between the coordinates of the two stations, then

$$(8) \quad \begin{cases} K \cos D_3 \cos A_3 = \rho_1 \cos \delta_1 \cos \alpha_1 - \rho_2 \cos \delta_2 \cos \alpha_2 \\ K \cos D_3 \sin A_3 = \rho_1 \cos \delta_1 \sin \alpha_1 - \rho_2 \cos \delta_2 \sin \alpha_2 \\ K \sin D_3 \qquad\quad = \rho_1 \sin \delta_1 - \rho_2 \sin \delta_2 \end{cases}$$

Multiply the first line of (8) by $\sin \alpha_2$, the second by $\cos \alpha_2$, and equate. Then

$$(9) \quad \rho_1 = K \cos D_3 \frac{\sin(\alpha_2 - A_3)}{\cos \delta_1 \sin(\alpha_2 - \alpha_1)}$$

In like manner,

$$(10) \quad \rho_2 = K \cos D_3 \frac{\sin(\alpha_1 - A_3)}{\cos \delta_2 \sin(\alpha_2 - \alpha_1)}$$

Now let α, δ be the geocentric coordinates of P; then the geocentric equatorial coordinates will be

$$(11) \quad \begin{cases} x = R \cos \delta \cos \alpha \\ y = R \cos \delta \sin \alpha \\ z = R \sin \delta \end{cases}$$

As also $x = X_1 + x_1 \quad y = Y_1 + y_1 \quad z = Z_1 + z_1$

$$(12) \quad \begin{cases} R \cos \delta \cos \alpha = R_1 \cos \phi_1' \cos \theta_1 + \rho_1 \cos \delta_1 \cos \alpha_1 = \\ \qquad\qquad R_2 \cos \phi_2' \cos \theta_2 + \rho_2 \cos \delta_2 \cos \alpha_2 \\ R \cos \delta \sin \alpha = R_1 \cos \phi_1' \sin \theta_1 + \rho_1 \cos \delta_1 \sin \alpha_1 = \\ \qquad\qquad R_2 \cos \phi_2' \sin \theta_2 + \rho_2 \cos \delta_2 \sin \alpha_2 \\ R \sin \delta = R_1 \sin \phi_1' + \rho_1 \sin \delta_1 = R_2 \sin \phi_2' + \rho_2 \sin \delta_2 \end{cases}$$

The second and third terms of each line should be solved in duplicate, as a check. It will be found that the check for x and y will be almost perfect—all the errors of observation will show up in the two values of z.

The height of P above sea level is

$$(13) \quad h = (R - R') \cos(\phi' - \phi)$$

where R' is the Earth's radius corresponding to ϕ'.
As $\cos(\phi' - \phi) = 1$ practically, $h = R - R'$.

To get the terrestrial longitude of P we have

$$(14) \quad \lambda = \lambda_1 + (\theta_1 - \alpha) = \lambda_2 + (\theta_2 - \alpha)$$

Having found the height at which the meteor appeared and disappeared, and

knowing the latitude and longitude of these points projected on the Earth's surface, from here on we may proceed as in the first method.

For reasons too complicated to enter into, this method is recommended only when the computer is fairly sure that the observations are good. Any attempt at adjustment, such as was explained for the first method given, would be impossible in Schaeberle's method. The experienced computer will also see that in (9) and (10) if $(\alpha_2 - A_3)$ or $(\alpha_1 - A_3)$ is near 0° or 180°, small changes in any one of the three quantities will produce large changes in ρ_1 or ρ_2. Similarly if $\alpha_2 - \alpha_1$ is near 0° or 180°, small changes in either α_1 or α_2 will produce great changes in ρ_1 or ρ_2. The same remark holds good if δ_1, δ_2, or D_3 is near 90°. In either case longer forms for ρ_1 and ρ_2 may be derived. These are:

$$(15) \quad \rho_1 = K \frac{\sin \delta_2 \cos D_3 \cos (\alpha_2 + A_3) - \cos \delta_2 \sin D_3 \cos 2\alpha_2}{\sin \delta_2 \cos \delta_1 \cos (\alpha_2 + \alpha_1) - \cos \delta_2 \sin \delta_1 \cos 2\alpha_2}$$

$$(16) \quad \rho_2 = K \frac{\sin \delta_1 \cos D_3 \cos (\alpha_1 + A_3) - \cos \delta_1 \sin D_3 \cos 2\alpha_1}{-\sin \delta_1 \cos \delta_2 \cos (\alpha_2 + \alpha_1) + \cos \delta_1 \sin \delta_2 \cos 2\alpha_1}$$

From here on the solution may be continued as before.

NOTE.—This method was first given by Schaeberle in "Contributions of the Lick Observatory," No. 5, 1895. Its slightly modified form, as given here, is taken from Olivier's "Meteors," 1925, Chapter XIV.

TUPMAN-KING METHOD

Another method, which has been used with great success by English observers, will now be explained. Its successful employment requires, however, the use of a good-sized celestial globe, which is not at everyone's disposal. It presupposes also that the meteor has been plotted by two observers, so that the right ascensions and declinations of both ends of its path, and the time of its appearance, are known.

One now proceeds as follows:*

(1) Plot the two recorded paths upon the globe and project them backwards until they intersect. This intersection is the radiant. Then carry forward each path until it intersects the horizon of its station or ship. This is known as Earth-point. Read off the α_r and δ_r of the radiant and the azimuth of each Earth-point.

(2) From the right ascensions and declinations of each end of the path, as observed at each station, calculate the corresponding altitudes and azimuths.

(3) Now prepare a map, as in first method, plotting S_1 and S_2 thereon, and the lines toward azimuths a_1, a'_2, a_2, a'_2.

(4) These lines intersect at B_1 and E_1, respectively. This is the ground line of the meteor. For the middle point of B_1, E_1, M, whose latitude and longitude can be read off the map, compute the altitude and azimuth of the radiant (h_r, a_r).

(5) Next plot, from each ship, the direction of the azimuth of the Earth-point. Produce these lines until they intersect at F.

*The full details of this method have been most kindly furnished the writer by A. King, F.R.A.S., the foremost English meteor authority, in a personal letter.

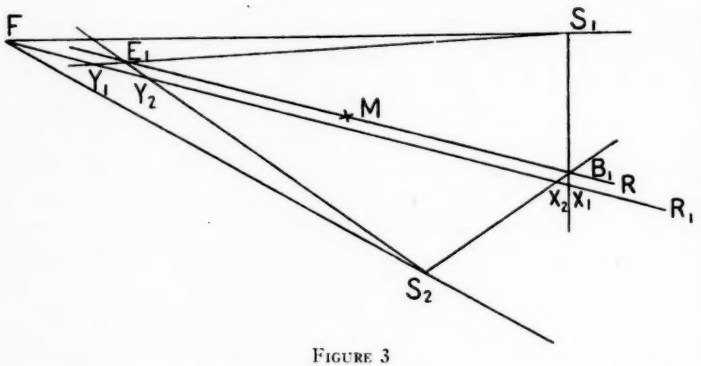


FIGURE 3

(6) Now from F draw a line FR^1 with azimuth equal to that of the radiant. If the observations are perfect, this will pass through M, but, in general, the line will be parallel to E_1MB_1 but not coincident with it.

(7) Let the intersections of FR^1 and S_1B_1, S_1E_1, S_2B_1, S_2E_1 be x_1, y_1, x_2, y_2, respectively.

(8) Measure distance S_2x_2, then
$S_2x_2 \tan (h_1 + \Delta) = H_1 =$ height of meteor at x_2, Δ being the correction for curvature of Earth's surface. Similarly $S_1x_1 \tan (h_1 + \Delta^1) = H_2$ gives the height of the meteor at x_1. For perfect observations $H_1 = H_2$; in the general case the best value for height will be a point z, halfway between x_1 and x_2. Then the height of the beginning point will equal $\frac{1}{2}(H_1 + H_2) = H_B$, where the observations are of equal weight.

(9) In exactly a similar way, we can find the height H_e of the end point. Let w be halfway from y_1 to y_2.

(10) Measure off $H_BH_e = P =$ projection of meteor's path. Then $P \sec h_r = L =$ length of meteor's path, where h_r is the altitude of radiant.

(11) Velocity $= L \div$ time the meteor was visible.

Checks:

(12) $P \tan h_r$ should equal $H_B - H_e$.

(13) $F_w \tan h_r$ should equal H_e.

This method, or modification thereof, appears to have been that mostly used by the English observers for a very long time. The great number and, in many cases, surprising accuracy of their results should be a very high recommendation for its use.

As outlined above, it is for two observers only. However, it can certainly be applied to more than two. In such cases it is far harder to lay down strict rules of procedure, because it is nearly always necessary to weight the observations. Perhaps it would usually be best to pick out the two apparently most accurate observations and make a preliminary solution. The others might then be "fitted in" and their deviations therefrom should soon show whether the choice was justified.

It is believed that the three methods outlined, none of which requires more

mathematical knowledge than spherical trigonometry and elementary practical astronomy, will fulfill the purposes of this article. For anyone who desires to go more deeply, particularly into cases where many observations are available, reference may be made to Bauschinger's "Bahnbestimmung der Himmelskorper," 1906, pages 593 *et seq.*

In some cases fireballs leave trains visible for from several minutes up to half an hour or more. Usually quite straight at first, these trains are caught by the winds blowing at high altitudes with different velocities and directions. The trains then change their shapes in fantastic ways. Accurate observations by observers which would permit the calculation of the heights of such trains give the meteorologist valuable information about the winds in the upper atmosphere. This is almost his only source, as sounding balloons do not penetrate so high. Drawings on a star chart at short intervals of time, which must always be given, furnish the best data. Mariners are particularly urged not to neglect such phenomena, as the number seen by any individual in a lifetime will be very small, and their importance is exceptional. If a star chart is not available, observations in altitude and azimuth will serve, but can scarcely give the same accuracy. If the train has lasted over five minutes, the ship's position should be given for both the first and the last observation.

We might mention that many fireballs will probably accompany the expected Leonid showers of November 14 to 18, which may occur in 1931, 1932, 1933, and 1934. Many fine trains will be left by these Leonids, so every effort should be made to secure such observations.

In closing it is proper to state that complete data on fireballs not only will permit scientists to deduce their heights, velocities, and orbits in space, but will help determine many things about our upper atmosphere which appear impossible of solution by any other means of approach. As the upper atmosphere must influence the lower, such results are of utmost interest to the navigator, professionally as well as intellectually, so that he too will eventually profit from these investigations.

(Published originally in November, 1931, at the Hydrographic Office, Washington, D. C., as a Supplement to the Pilot Chart of the North Atlantic Ocean for 1931.)

Flower Observatory, Upper Darby, Pennsylvania.

Contributions of the Society for Research on Meteorites

Edited by **FREDERICK C. LEONARD**
Department of Astronomy, University of California, Los Angeles 24

The Average Composition of Meteoritic Iron*

JOHN DAVIS BUDDHUE
99 South Raymond Avenue, Pasadena 2, California

*The symbols used for the various classes of meteorites referred to in this paper are the same as those listed in F. C. Leonard's "Studies of the Meteoritic Falls of the World: 6," Table 1, *C.S.R.M.*, **3**, 223; *P. A.*, **53**, 466, 1945.

ABSTRACT

Average analyses are given by type and as a whole for iron meteorites (siderites, Si), based on selected analyses of 327 siderites. Average compositions are given also for pallasites (P), mesosiderites (Ms), and for the metallic part of chondrites (C). The composition of meteoritic iron appears to be very nearly the same, regardless of whether it occurs alone or in combination with silicate material.

The idea of computing the average composition of meteorites, or of any group or type of meteorites, is not new. G. P. Merrill has published an average composition of stone meteorites (aerolites, A), based on 63 analyses which he considered satisfactory.[1] O. C. Farrington has done the same thing, using the analyses of 125 aerolites.[2] He has published also an average analysis of 318 siderites (Si). He notes that "about 60 obviously imperfect" analyses were excluded. Berwerth and Michel have given average analyses of all of the important classes of siderites, based upon a total of 415 analyses.[3] All 415 analyses are reprinted, and some are obviously faulty, but no effort seems to have been made to exclude any. Tschirwinsky's average for all siderites (based on 360 analyses) and his average for 10 pallasites (P) also are quoted by Berwerth and Michel. A number of good analyses of siderites have appeared in recent years; as I am not certain, however, that only the best available material has been used in previous work on the subject, I have undertaken to recalculate the average composition of siderites, both by classes and as a whole, using only those analyses which I consider to be probably reliable. Various criteria of reliability were employed. In general, an analysis which departed from previously calculated averages for its class by 2% or more was excluded. Where several analyses of a single siderite were available, only those agreeing among themselves were included. Analyses which were obviously incomplete were not included. In a few cases, determinations of single components were excluded from the average, when they alone, in the analysis, seemed to be in error. When 2 components were determined together, they had obviously to be excluded from the average, altho the rest of the analysis was ordinarily used. Averages were computed by adding all of the determinations of element x, and then dividing by the number of analyses in which x was determined. It is understood that this method may tend to give high values, but the alternative of dividing by the total number of analyses may give low values

TABLE 1

Element	H	Ogg	Og	Om	Of	Off
Fe	93.59%	92.33%	91.22%	90.67%	90.53%	86.75%
Ni	5.57	6.54	7.39	8.22	9.00	11.65
Co	0.66	0.50	0.54	0.59	0.57	0.61
Cu	0.35	0.01	0.18	0.03	0.05	0.11
P	0.29	0.16	0.18	0.18	0.17	0.24
S	0.06	0.02	0.08	0.09	0.08	0.63
C	0.19	0.23	0.21	0.08	0.61	0.01
Misc.	0.19	0.27	0.54	0.30	0.18	0.45
	100.90	100.06	100.34	100.16	101.19	100.45
Sp. gr.	7.727	7.714	7.394	7.673	7.708	7.733
No. anal.	48	20	40	126	43	13
No. Si	34	18	34	92	37	10

Element	D_1B	D_2S	P	Ms	C	All Si
Fe	79.63%	91.07%	88.20%	89.47%	88.99%	89.70%
Ni	18.85	6.88	10.35	8.52	9.54	9.10
Co	1.01	0.54	0.47	0.54	0.58	0.62
Cu	0.05	0.19	0.57	....	0.10	0.04
P	0.12	0.18	0.16	0.21	0.03	0.18
S	0.08	0.06	0.17	....	....	0.08
C	0.10	0.08	0.01	....	....	0.12
Misc.	0.19	0.17	0.52	....	1.90	0.34
	100.03	99.17	100.45	98.74	101.14	100.18
Sp. gr.	7.299	7.643	7.32			
No. anal.	38	30	17	9	44	428
No. Si	24	14	14	9	41	327

In most cases the sums exceed 100%. There are 2 reasons for this fact. Most of the individual analyses, also, total slightly more than 100%. It may be also a result of the fact that the method of averaging may give slightly high figures. The total for mesosiderites (Ms) is low because there were so few determinations of certain components that averages would be meaningless. The total of the metal from chondrites (C) is high, probably because of the unusual amount of "Miscellaneous," which in this case is probably silicate material. The "Miscellaneous" includes usually such minor components as Cr, Mn, *etc.* "All Si" does not, of course, include the metal from the chondrites (C), but it should be noted that these 2 kinds of meteoritic iron are nearly the same in composition.

In compiling the analyses, it was observed that the analyses of fine octahedrites (Of) seemed to fall into 2 groups differing in nickel content. If histograms of the nickel content of any other class are constructed, single maxima will be found, but, in class Of, 2 maxima separated by about 3% are found. The compositions of the 2 groups were calculated and found to be as follows:

TABLE 2

Fe	Ni	Co	Cu	P	S	C	Misc.
90.00%	8.30	0.59	0.05	0.17	0.09	0.04	0.14: 99.38
89.80%	11.50	0.50	0.04	0.21	0.02	0.05	0.35: 102.47

The first average is based upon 34 analyses of 28 siderites with an average specific gravity (sp. gr.) of 7.704. The other is based upon 9 siderites, whose specific gravity averages 7.716. The smallness of the sample probably accounts for the excess in the sum. Comparison with the averages for classes Om and Off strongly suggests that, as far as chemical composition is concerned, there is *no* class Of.

The chief difference between my averages and those of Berwerth and Michel is that mine show a higher nickel content. Since the analyses I rejected were largely those which showed too small amounts of nickel, I infer that the averages of those investigators contain a number of erroneous analyses. It should be pointed out that it is very easy to obtain a low figure for nickel, unless special precautions are taken to prevent it, and that the older methods of determining nickel are precisely those most likely to introduce this sort of error. This error may amount to several per cent,[4] yet it does not show up appreciably in the summation of the analysis. The reason for this fact is that the undetected nickel is determined with the iron, and, as the atomic weights of these two elements are close together, the sum is nearly what it would be if the analysis were accurate.

Nickel increases, of course, from class H to class D_1B. Copper, sulfur, and

especially cobalt also tend to increase with nickel, while carbon probably decreases. This tendency is not apparent in the older averages. Type D_3S consists possibly of altered members of the other types, but, if so, the nickel content should approach the average for all siderites. It obviously does not do so. Pallasites (P) and mesosiderites (Ms), especially if combined, do approach the average for all the siderites. The inclusion of an average for the metal in chondrites (C) is new. Kunz and Weinschenk have suggested that the nickel content of chondrites is higher than that of siderites.[5] This statement is true if the chondrites are compared only with the numerous medium octahedrites (Om), but the average nickel content of the chondrites is very close to that of all other kinds of meteoritic iron; so the nickel content of chondrites has presumably about the same range as that of siderites.

REFERENCES

[1] G. P. Merrill, *U. S. Nat. Mus. Bull. 149*, 47, 1930.
[2] O. C. Farrington, *Field Mus. Publ. 151, Geol. Ser.* **3**, No. 9, 211, 1911.
[3] F. Berwerth and H. Michel in C. Doelter's *Handbuch der Mineralchemie*, **3**, 2 Hälfte, 574-607, 1926.
[4] E. P. Henderson, *Am. Jour. Sci.*, **239**, 372-8, 1941.
[5] G. F. Kunz and E. Weinschenk, *Am. Jour. Sci.*, **43**, 65, 1892.

A Note on the Chemical Elements Not Found in Meteorites

JOHN DAVIS BUDDHUE
99 South Raymond Avenue, Pasadena 2, California

Of the 92 known elements, nearly all have been found in meteorites. The few that have not so far been reported in stones, irons, or in troilite are the following:

Element	*Symbol*	*Atomic No.*
Illinium	Il	61
Xenon	Xe	54
Krypton	Kr	36
Virginium (Ekacaesium)	Vi	87
Alabamine (Ekaiodine)	Ab	85

The first and the last two are extremely rare on Earth. In fact, what is known of their chemical properties has been learned chiefly from the study of minute samples prepared by nuclear reactions of neighboring elements in the periodic system. Xenon and Krypton also are very rare, and, had they not occurred in the atmosphere, they would probably have remained unknown on Earth for a long time to come. It is therefore not surprising that they have not yet been detected in meteorites. I have not much doubt, however, that they too are present in minute quantities.

Meteorites contain no elements not known on Earth. It would be very surprising if they did. It is interesting to observe in this connection that about 66 elements have been identified in the atmosphere of the Sun.

"Crater Mound, Arizona"

Under the title of "Crater Mound, Arizona," the following abstract by N. H. Darton appeared in *Bull. Geol. Soc. Am.*, **56**, No. 12, Pt. 2, 1154, Dec., 1945:

"My geological map of Arizona was recently reprinted with repetition of the name Crater Mound for the wonderful rock upburst about 20 miles west of Winslow. This name, which has been established officially by the U. S. Board of

Geographic Names since 1932, was used and reused in my *Résumé of Arizona Geology*, Guide Book of Geology along Santa Fe Railroad (*U.S.G.S. Bull.* 613), and geologic and topographic maps of Arizona. The words 'Meteor Crater' are not admissible. I am convinced that no meteorite is present, a matter which I discussed in a paper on *Explosion Craters*, printed in *Scientific Monthly* in 1916. Extensive shafting and drilling have given entirely negative results as to the presence of buried meteor[it]ic iron, and a geophysical survey verified the magnetic tests made for Gilbert. I submitted a plat of this survey (in A.I.M.E.) to one of our most eminent geologists, and he stated that it proved the absence of a meteorite. My present hope for Crater Mound is to have it made a national monument. To anyone interested in such craters I advise a visit to closely comparable Zuni Salt Lake in western New Mexico. It has an encircling rim of fragments ejected from great depth, as in Crater Mound, but has a volcanic cinder cone in the center of its bottom, proving volcanic eruption at the end."

There are two points in this abstract to which we can agree: (1) that the name "Meteor Crater" should be changed, albeit not to "Crater Mound" but to "Meteorite Crater"; and (2) that the Crater should be made a national monument or, we may add, a national or State park. The amazing thing is, however, that any geologist should still disbelieve in the meteoritic origin of what is undoubtedly the finest example of meteorite crater known on the Earth!—F.C.L.

On the Place and Name of the Ehrenberg, Yuma Co., Arizona, Fall

A recent check of the meteoritic falls of the United States has disclosed that a fall listed on p. 72 of Coulson's catalog (1940) as "Colorado River, La Paz, Yuma Co., *New Mexico*, U.S.A. Found 1862. Synonyms: Ehrenberg; La Paz. Iron. Coarse octahedrite, Og," is, as correctly recorded on p. 19 of the appendix to Prior's catalog (1927), none other than the "Ehrenberg, Yuma Co., *Arizona*," fall. The same mistake in the name and location of this fall was made earlier, on p. 43 of Prior's catalog (1923), but, as just pointed out, the error was corrected in the 1927 appendix.

The provisional coördinate number (P.C.N.) of the Ehrenberg fall is 1145,-335. "La Paz" appears to have been the original name of a small place on the Arizona side of the Colorado River, which later was renamed "Ehrenberg," evidently in honor of one H. Ehrenberg, the finder of the meteorite.—F.C.L.

What Is a Comet?

In view of the established connection between comets and meteorites (*cf.* any good up-to-date textbook on astronomy; *e.g.*, Russell, Dugan, and Stewart's, Vol. I, Ch. 13, pp. 408-62, Rev. Ed., 1945), the question "What is a comet?" is very satisfactorily answered by the following definition of a

Comet: a swarm of meteorites [the nucleus] and their concomitant exhalations [the coma and the tail] in motion thru space.

In accordance with this definition, the only feature that distinguishes a comet from a swarm of meteorites in space is the "concomitant exhalations" that constitute the coma and the tail of the comet.—F.C.L.

The Research Associateships in the Institute of Meteoritics of the University of New Mexico

According to President J. P. Wernette of the University of New Mexico, Albuquerque, "The Research Associateships in the Institute of Meteoritics of the University of New Mexico are complimentary appointments made in recognition of individual contributions of outstanding importance in the field of meteoritics. Appointees to these positions will be listed as honorary members of the staff of the Institute of Meteoritics and will be accorded the research and publication facilities provided by the Institute."

The following persons have recently been appointed to Research Associateships in the Institute, of which Dr. Lincoln La Paz, the President of the Society for Research on Meteorites, is Director (see *C.S.R.M.*, **3**, 220; *P. A.*, **53**, 409, 1945):

Dr. Frederick C. Leonard, Professor and Chairman of the Department of Astronomy, University of California, Los Angeles, and Editor and Ex-President of the Society for Research on Meteorites; Dr. Henry F. Dunlap of the Research Staff, New Mexico Proving Ground, Albuquerque, New Mexico; Dr. Helmut E. Landsberg, Department of Meteorology, University of Chicago, Chicago, Illinois; Dr. C. C. Wylie, Professor of Astronomy, State University of Iowa, Iowa City, and Ex-Vice-President of the Society for Research on Meteorites.

President of the Society: LINCOLN LA PAZ, Department of Mathematics and Institute of Meteoritics, University of New Mexico, Albuquerque

Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, P. O. Box 9866, Los Feliz Station, Los Angeles 27, California

---

Comet Notes

By G. VAN BIESBROECK

The first new comet of 1946 was found by M. Timmers at the Vatican Observatory at Castel Gandolfo near Rome. The discovery was reported by the director, Father J. Stein, who gave the following data:

1946 February 2.00757 U.T.
Right ascension $9^h\,47^m.5$ Declination $+42°\,24'$
Magnitude 9
Daily motion $1^m\,41^s$ West and $1°\,12'$ North

The comet being favorably situated in the constellation of Ursa Major it was observed at once at several observatories. Besides, its images were recognized on four prediscovery plates taken at the Harvard College Observatory between January 23 and 29. From the material available up to February 8, L. E. Cunningham has computed a preliminary parabolic orbit, with elements as follows:

Date of Perihelion Passage	1946 April 18.820 U.T.	
Node to perihelion	$58°\,29'$	1946.0
Node	$128°\,46'$	
Inclination	$72°\,18'$	
Perihelion distance	1.6763 A.U.	

From these I have computed this ephemeris for March, which shows that the comet has moved from Ursa Major in Camelopardus and will remain circumpolar for quite a while. The brightness changes very slowly. In February it was rising a little but reached a maximum in the middle of that month. I have

assumed 10^m for March 9 and the following figures show the slow decrease expected. The decrease in distance from the sun as the comet approaches perihelion is more than counteracted by the increasing distance from the earth.

EPHEMERIS OF COMET TIMMERS

		α	δ	
		h m	° ′	m
1946	March 9	7 54.9	+71 46	10.0
	18	7 14.6	74 3	10.1
	27	6 44.1	75 23	10.2
	April 4	6 24.9	76 49	10.3

Shortly after discovery the comet appeared as a small nebulosity well condensed into a central nucleus; there was an indication of a short tail in a direction opposite to that of the sun, but the moon interfered with the observation. As the comet approaches perihelion the tail will probably be more pronounced but, since it remains at a large distance from the sun, no great physical changes are to be expected.

Nothing further has been learned about the two comets FRIEND-PELTIER and DUTOIT that were found at the end of last year. They will remain lost in the glare of the sun for some time and their location will be quite uncertain when they emerge in the night sky as faint objects.

The only other known comet under observation is PERIODIC SCHWASSMANN-WACHMANN 1925 II. Last month we reported it as extremely faint in December and in early January. What a surprise when January 25 I looked for it again! It had risen to magnitude 10.2 on the Harvard Scale and appeared as a sharp disc of only 8″ in diameter. January 26 it had risen to 9.4 and remained at 9.5 on January 28 when it had become less sharp, the disc having increased to 20″ and showing a diffuse edge. Once more we have here a bright outburst of this remarkable object as has occurred off and on but quite unpredictably in the past. The outburst did not last very long; by February 8 the total brightness had dropped to magnitude 15 and the comet appeared as a fuzzy coma some 45″ in diameter. Attention is once more called to the need of continuous watching of this erratic object.

Williams Bay, Wisconsin, 1946 February 12.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Astronomers Aid in Study of the Structure of the Atom*

On August 28, 1945, the Swedish astronomer, Tamm, discovered a star of the magnitude of 8.5 in the constellation of Aquila. A cabelgram to that effect was received by Sternberg of the State Astronomical Institute in Moscow on September 1 and that same night the star was photographed by astronomer T. S.

*Communicated by the Soviet News, 518 Grand Buildings, Trafalgar Square, London.

Chernova, who thus confirmed the discovery. The star was found to be of the magnitude of 7.9 which is brighter than Tamm reported. Information about the new star has also been received from A. Solovyev, Director of the Stalinabad Observatory. Observations are continuing.

A newly-discovered star is one of the so-called *novae* or "new stars" of which more than 150 are known. Incidentally the term "new star" is misleading; at one time it was thought that new stars actually do come into being, but subsequently it was established that long-existing faint stars suddenly blaze out.

We are able to observe these outbursts only once or twice a year. Actually about 30 occur annually but most of them are not detected. Spectral observations have established that in all cases the outburst of the phenomenon is the same. For reasons still unknown a star increases hundreds of times in size and tens of thousands of times in brilliancy. When the star attains its maximum size and brilliance a thin gaseous nebula separates from its surface. Expanding outward it gradually disperses into space and the star itself dwindles in size and brilliance turning into a so-called "white dwarf." This process takes several years.

Many astronomers have wondered whether something similar might happen with the sun. Might not the sun suddenly blaze out with the result that not only life on earth but the sun itself would inevitably burn up? Such a viewpoint was supported about fifteen years ago by some astronomers abroad.

Not long before the war, however, astronomer B. V. Kukarkin, in collaboration with myself, showed that our earth was not threatened by any solar "outburst." Analyzing the observations of astronomers here and abroad we discovered that there is a definite category of stars, "white dwarfs," which blaze out as new stars once in 3,000 years on an average. The sun does not belong to this group of stars.

In the galaxy there is a very small number of "white dwarfs" (compared to the total number of stars) approximately 30 times 3,000 or about 100,000. From time to time they blaze out and produce the phenomena of new stars.

The luminosity of stars is due to the complex transformations of elements of nuclear reactions causing a slow transformation of hydrogen into helium. The assumption may be made that in the "white dwarfs" a process goes on that leads every 3,000 years or so to release a nuclear chain of reaction, an instance of atomic disintegration which is accompanied by the liberation of intra-atomic energy and the phenomenon of a new star blazing out.

The "white dwarfs" were first observed only some 20 years ago. One that has been studied most is the companion of Sirius, the brightest star in the heavens. The volume of this companion is one-millionth that of its primary. Its mass, however, has been found to be two-fifths of that of the primary. This indicates that the companion star has a density 400,000 times that of Sirius itself.

Osmium has the greatest density of all substances known on earth, 1 cubic cm. of this metal weighing 22.5 grams, or 22.5 times as much as an equal quantity of water. A cubic centimeter of material of the companion of Sirius would weigh 50 kilograms if we were to weigh it here on earth. A matchbox filled with it would weigh half a ton.

Subsequently other stars with as great and even greater density have been discovered. All of them are characterizd by a white light and are very small in size, although they have a mass that is normal for ordinary stars. It is these stars that are called "white dwarfs." That with the greatest density was dis-

covered by the Dutch astronomer Keper. Its radius is half the earth's radius but its density is 36 million times that of water.

In matter in this state all outer electrons are absent and the atomic nuclei are closely packed together. No man-made laboratory has yet been able to organize matter in this way. Stars, however, can serve us as gigantic laboratories, as it were, for studying matter in states we cannot produce and hence promise much for the progress of physics.

In cosmic space matter is encountered also in a highly rarefied state. There are stars whose density is one-millionth of the density of air at the earth's surface. Densities of a thousand billion times less are also known. Therefore the study of heavenly bodies enables us to delve deeper into the structure of the atom and the atomic nucleus with its incalculable reserves of energy.

P. PARENGA.

General Notes

Professor J. H. Oort, recently appointed director of the Leiden Observatory, Leiden, Holland, has been awarded the Gold Medal of the Royal Astronomical Society, London, England.

Dr. Henry Norris Russell of Princeton University received the award of the Order of the Aztec Eagle, Mexico's highest award to persons outside that country, at the recent meeting of the American Astronomical Society in New York City. At the same time a contribution of $1,000 was made to the Henry Norris Russell Lectureship Fund, a gift from the president of Mexico, Manuel Avila Camacho. Dr. Harlow Shapley of Harvard College Observatory also is a member of the Order of the Aztec Eagle.

The Retirement of Dr. Young

Dr. R. K. Young has resigned the position of Professor of Astronomy in the University of Toronto and Director of the David Dunlap Observatory. The absence of members of the staff on military duty during the long years of the war rendered the work of observing hard to maintain, and the weather conditions of the winter of 1944-5 made conditions still more difficult. As a consequence Dr. Young's health suffered and he decided to retire and leave the work to younger hands. He hopes to spend some time in travel.

His successor as head of the Department and of the Observatory is Dr. Frank S. Hogg, who has been a member of the staff from the establishing of the Observatory. As all our readers know, Dr. Hogg is Assistant Editor of this *Journal* and of the *Observer's Handbook*. He is past president of the Royal Astronomical Society of Canada, vice-president of the Toronto Centre of the Society, a member of the Council of the Royal Canadian Institute and a member of the Navigation Sub-committee of the National Committee on Aeronautics. —C.A.C.

(From the *Journal of the Royal Astronomical Society of Canada,* **60**, 44.)

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on February 8, 1946, at the Morgan Physics Laboratory, University of Pennsylvania. Mr. George V. Plachy, Secretary of Amateur Astronomers As-

sociation, spoke on the topic, "New York Amateur Astronomers Expedition — Total Solar Eclipse of July 9, 1945."

Eclipse Plans for 1947.—An expedition to observe the solar eclipse of May 20, 1947, in the vicinity of Montes Claros, Brazil, is being organized jointly by the National Geographic Society and the Bureau of Standards of Washington. Professor G. Van Biesbroeck of the Yerkes Observatory has been asked to join the group for the purpose of making a new determination of the shift in star positions in the eclipsed field as predicted by the theory of relativity.

Catalogue of Technical Books

A new catalog of technical books has just been issued by The Chemical Publishing Co., Inc., 26 Court Street, Brooklyn 2, N. Y. This catalog includes the latest books on chemistry, physics, science, technology, medicine, foods, formularies, drugs and cosmetics, engineering, metals, technical dictionaries, building construction, etc.

This catalog, conforming with the requests of technical and scientific workers and librarians, gives the date of publication of each book as well as price, number of pages, detailed descriptions and full table of contents.

A copy of this catalog will be sent free to everyone who is interested in keeping up with the latest technical and scientific progress.

Astronomers Contribute to Encyclopaedia Britannica

Four astronomers have made their first contributions to the *Encyclopaedia Britannica* for the 1946 printing of the 178-year-old reference work.

These new Britannica contributors are: Walter S. Adams, director of the Mount Wilson Observatory, who has written a revision of the article on "astronomical observatories"; Gerald M. Clemence, assistant director of the *Nautical Almanac*, U. S. Naval Observatory, who has revised the article on "time measurement"; Seth Barnes Nicholson, astronomer at the Mount Wilson Observatory, author of a new article on "Pluto" and a revision of "Neptune"; and Dirk Brouwer, editor of "The Astronomical Journal" and Munson professor of Natural Philosophy and Astronomy and director of the Observatory at Yale University, who has prepared the articles on "celestial mechanics" and "Trojan planets."

Several thousand experts have revised, rewritten or prepared new articles for the 1946 printing of the *Encyclopaedia Britannica* under its plan for continuous revision.

A Correction

Mr. G. M. Clemence, Director of the *Nautical Almanac* Office, has called attention to an error of statement on page 32 of the January, 1946, issue of POPULAR ASTRONOMY relative to the Eclipse of June 29. In the words of Mr. Clemence, the correct statement concerning this eclipse would be, "According to the data given in the *American Ephemeris and Nautical Almanac* for 1946, page 325, the maximum phase of this eclipse occurs in Greenland, Lat. +50° 49′, Long. +66° 36′, and not near Archangel, Russia, where it is not visible. This eclipse begins in the North Sea and ends a few degrees east of Great Slave Lake in Canada. It is a partial eclipse of the midnight sun."